Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

MARCH, 1913.

ELECTRIC WAVES.

By W. D. EGGAR, M.A.

MIDDLE-AGED people, like the writer, may still be found who will answer, when asked the meaning of the word *electron*, that it is the Greek name for amber. This is admittedly true, but it will probably be unsatisfactory to the questioner, who will be expecting much more up-to-date information. Modern text-books, if we may include anything published within the last twenty years as modern, will suggest many different definitions of the sub-atomic bodies on which Dr. Johnstone Stoney, with a somewhat misplaced generosity, bestowed the title of electron. They are centres of strain in the ether, cathode rays, β-particles, bricks of which atoms are built, ends of Faraday tubes. The mass of an electron is given as $6{\cdot}1\times10^{-28}$ grammes, and its radius as 10^{-13} centimetres, and some persons with a taste for figures may feel some small satisfaction in this information.

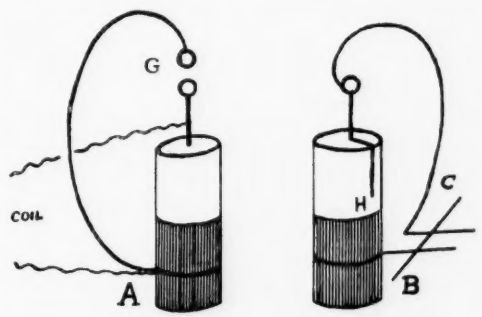


FIGURE 71.

FIGURE 72.

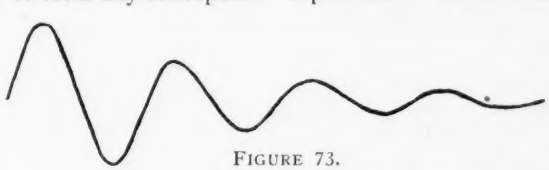


FIGURE 73.

It is still open to anybody to form any conception that he may find possible of the ultimate structure of space; but certain facts about the aether are becoming part of our common life, and are even a subject of inquiry for a Parliamentary Committee. Whether we regard an electron as a whirlpool in a continuous medium, or as the terminus of a Faraday tube in an aether of which the structure is fibrous, there seems to be no question that movements of electrons are accompanied by a disturbance of the adjacent medium, and that this disturbance travels along the medium, whatever its structure, with a velocity of 3×10^{10} centimetres, or approximately one hundred and eighty-six thousand miles per second.

Wireless telegraphy is accomplished by a succession of electric, or electro-magnetic disturbances, propagated as waves through space. It is remarkable that Britain had furnished the theory of these waves before their existence was demonstrated practically on the Continent. Sir J. J. Thomson, in "The Encyclopaedia Britannica" (XIth Edition), points out that Lord Kelvin, in 1853, proved from theory that the discharge of a Leyden jar must be oscillatory. Feddersen proved it by experiment. Clerk Maxwell proved that, on his theory, electro-magnetic waves must travel through space with the velocity of light. Hertz, in 1887, demonstrated the existence of these waves, employing as the source of disturbance an oscillatory spark-discharge. He found that such a discharge would produce small sparks between the ends

of a copper wire bent nearly into a circle.

It has been said already that the discharge of a Leyden jar is oscillatory. Lodge devised a method of obtaining a persistent oscillatory discharge, and of tuning a receiver for it. The transmitter consists of

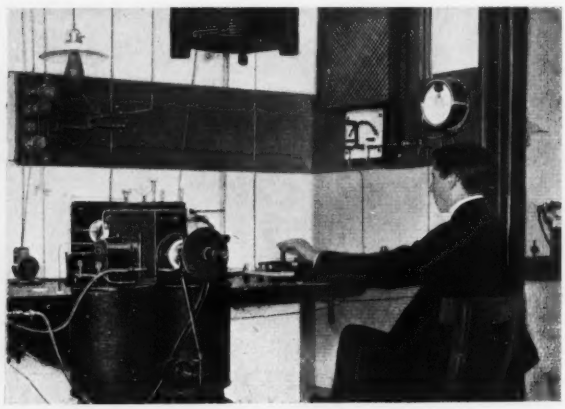


FIGURE 74.

Transmitter at the Lyngby Station.

a Leyden jar A. (Figure 71) with a bent wire nearly connecting the outer and inner coatings, which are themselves connected to the terminals of an induction coil. When the coil is working, a persistent series of oscillatory sparks crosses the air-gap G. The receiver is another Leyden jar B, also with a bent wire, with an air-gap H, the planes of the two bent wires being parallel to each other and at right angles to the line joining the centres of the jars. The sliding piece C can be adjusted so that when A is at work sparks pass across the gap H. A very slight displacement of C causes the sparks to cease.

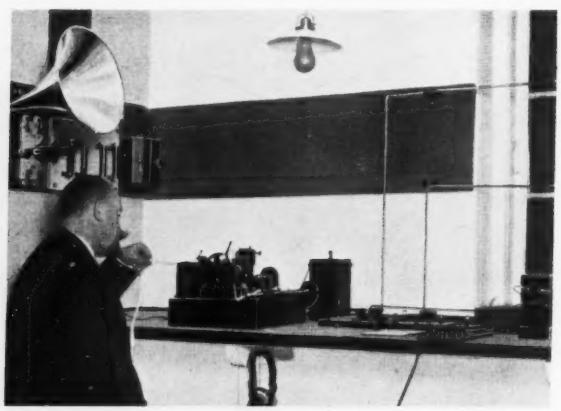


FIGURE 75.

Receiver at the Lyngby Station.

Now, although such a transmitter and receiver can be made very perfectly *in tune* with each other, such a receiver is not sufficiently sensitive for long-distance work. Electric waves produce various other effects which can be employed to detect their presence. Branly discovered that the resistance between loose metallic contacts is diminished when electric waves fall on them, and the detectors made on this principle are known as *Coherers*. Rutherford found that a bundle of iron wires magnetized to saturation was demagnetized by the alternating currents caused by electric waves. Marconi's magnetic detector employs this discovery in the form of an endless flexible iron wire, made to move round and round by clockwork under permanent magnet poles; the changes in the magnetization caused by the electric waves induce currents in a telephone receiver. Such detectors can be tuned to show maxima effects for waves of particular lengths, but the effects do not cease completely for other wave lengths.

It has been said that the electric waves generated by the discharge of a Leyden jar may be compared to the sound waves produced by a pistol-shot. Perhaps it would be fairer to compare them to the waves produced by a drum-tap. There is at least a very rapid damping of the waves, *i.e.*, a rapid falling off in their intensity, although the wave length, *i e.*, the distance between successive crests, may remain the same. (See Figure 73.) The waves of a sound of a drum would produce in the groove of a gramophone record hills and valleys similar to those shown in Figure 73. The record of a tuning fork, however, would be more like Figure 72. So would the record of an organ pipe, so long as a stream of air is being driven across its embouchure. Analogies are sometimes misleading; but in seeking analogies between different kinds of waves we are not likely to go far wrong if we bear in mind the main characteristics of all wave motion and the main specific peculiarities of each kind.

In all wave motion we find the following characteristics, among others :–

(i) The disturbance takes time to travel from one place to another. Electric waves travel one hundred and eighty-six thousand miles per second, waves of sound in air about one thousand one hundred feet per second.

(ii) A medium to transmit the disturbance is necessary. The medium for electric waves is generally spoken of as the aether; sound usually travels to our ears in air.

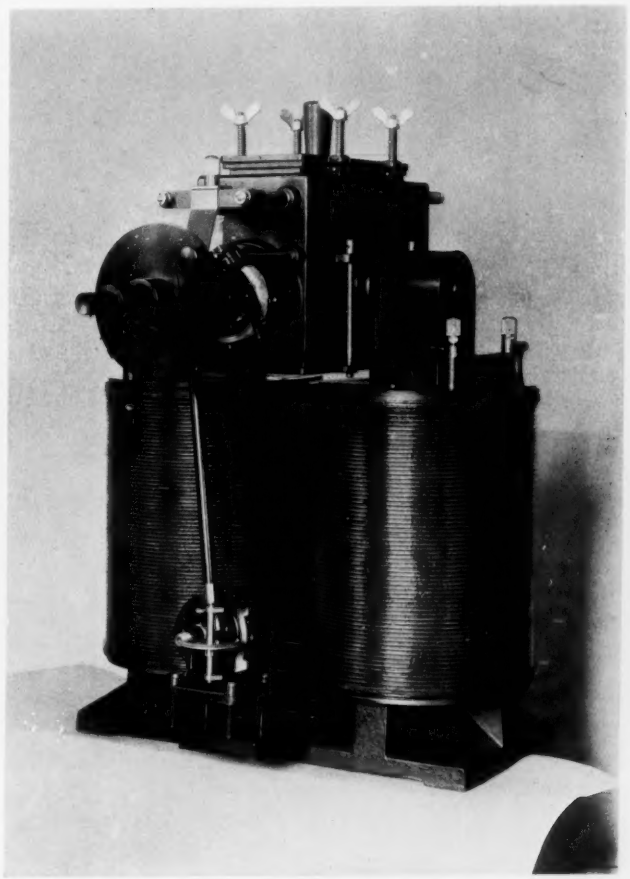
(iii) When waves follow each other at regular intervals and fall on some system capable of being disturbed by them, then if that system has a natural period of vibration corresponding to the period of the waves, it will be caused to vibrate in sympathy with them. This phenomenon is known as resonance, and numerous familiar instances of it might be recalled.

(iv) The velocity of the waves, the wave length, and the frequency are connected by the equation $V=NL$. For instance, let us take a tuning fork giving two hundred and seventy-five vibrations per second; the waves travel

with a velocity of one thousand one hundred feet per second ; therefore, the space between each wave and the next will be four feet. Again, suppose an electric oscillator sending out one million waves per second. The wave length must be three hundred metres, since the velocity of propagation is 3×10^{10} centimetres per second.

The frequency of an ordinary alternating current is far too low to produce waves of sufficient energy for use in wireless telegraphy. In 1899 Duddell discovered the following phenomenon :—When a condenser of suitable capacity is connected through a self-induction coil in parallel with an electric arc which is being fed by direct current, the arc will, under certain conditions, become musical. At the same time there is set up in the self-induction an alternating current, having the same rate of vibration as the note produced by the arc. In other words, part of the direct current is transformed into an alternating current of constant amplitude, the energy absorbed being supplied by the direct current.

A very close analogy to Duddell's musical arc may be found in a flue organ pipe. Here the note is produced by the vibrations of the air column in the pipe, whose dimensions determine the pitch of the note. These vibrations would die away, or be *damped*, very rapidly but for the energy supplied by the continuous current of air blown across the embouchure of the pipe. This air current is directed against a sharp edge, and must pass either inside or outside it, thus creating either a compression or a rarefaction at the end of the pipe. The natural frequency of the pipe causes the air current to be turned alternately inwards and outwards, and the note is maintained, the air current supplying the energy and paying the piper, the organ pipe calling the tune.



From a photograph by W. Duddell.

FIGURE 76.
A Twelve Kilowatt Generator.

By this method Duddell obtained a high rate of alternation : that is to say, up to thirty or forty thousand oscillations per second. Even this rate is too low for wireless telegraphy, and the energy far too feeble. In 1903, however, Professor Valdemar Poulsen, of Copenhagen, succeeded in obtaining a much higher rate of oscillation by surrounding the arc with an atmosphere containing hydrogen. Hydrogen, with its high atomic velocity, possesses great thermal and electrical conductivity, and no doubt its cooling influence makes it possible to use higher power. Poulsen further discovered that a strong magnetic field placed transversely to the arc had the effect of giving a definite shape to the arc and thus making the oscillations more constant, as well as making it possible to increase the potential difference greatly in proportion to the length of the arc. By these two devices Poulsen has obtained alternations as rapid as one million per second.

It is claimed for the Poulsen-Pedersen system of wireless telegraphy that it is capable of being tuned with greater precision than any spark system. If a tuning fork in vibration is held over an open piano, only one wire will show resonance. On the other hand a pistol shot will make all the wires vibrate at the same time.

Another claim is that a speed comparable with that of submarine cables can be attained by the Poulsen automatic transmitter (Figure 74). With this, as in the Wheatstone instrument, the message to be sent is represented by a series of holes punched in a continuous paper strip, those on one side of the central line representing dots, and those on the other side dashes. This strip is fed into a rotating contact maker, and by means of the holes the continuous waves of the arc are cut up into lengths, short for the dots and long for the dashes. The aërial wire at the receiving station picks up these wave trains, and transmits them to a crystal rectifier

consisting of particles of galena and tellurium in contact, which permits the current to pass, in one direction only, through a "string" galvanometer. A shadow of the string is projected on to a moving strip of sensitive paper, which passes on into developing and fixing baths, so that a permanent record of the vibrations of the string is obtained, similar to that of Lord Kelvin's siphon recorder, which is shown in Figure 75, at the bottom of page 82.

The system has been tried successfully between Lyngby, in Denmark, and Cullercoats, at the mouth of the Tyne, a distance of six hundred miles. Whether it will work as well between Ireland and North America remains to be seen.

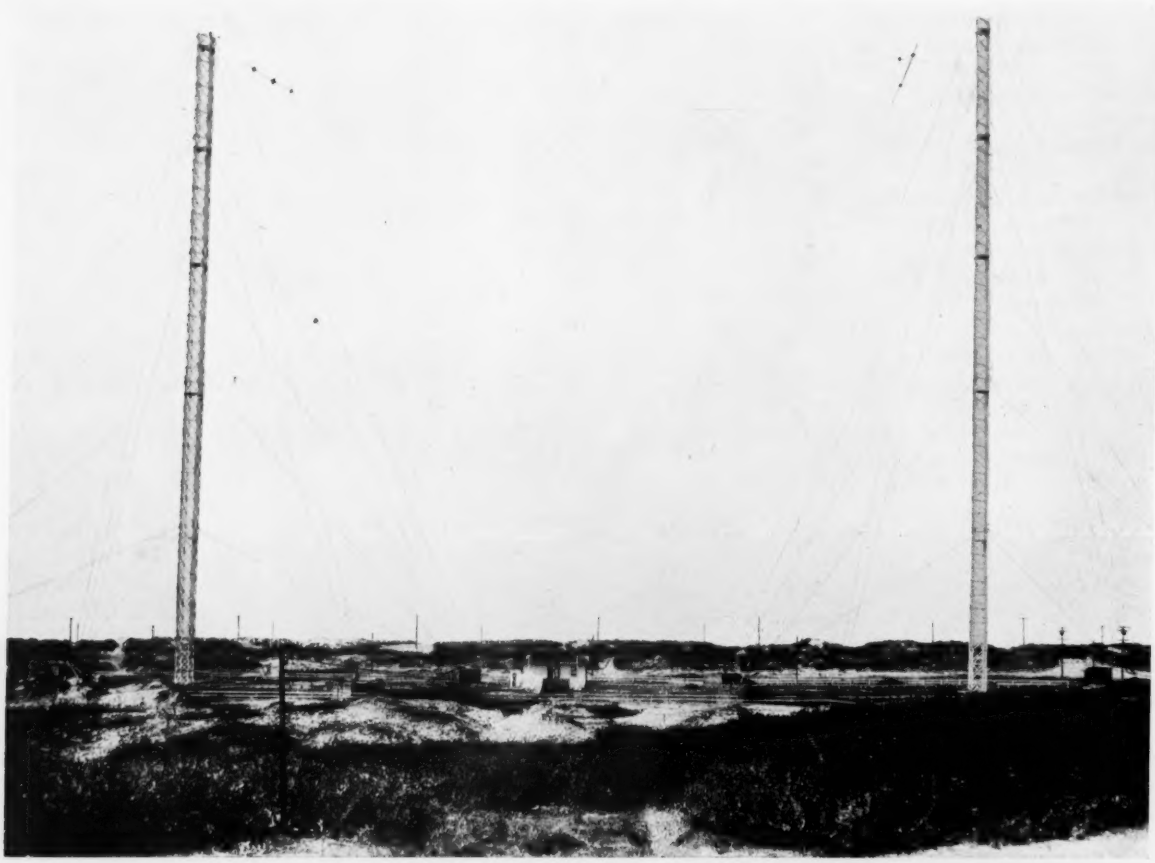


FIGURE 77. Poulsen Masts, San Francisco, California (U.S.A.)

The merits of the various rival systems are still *sub judice*. The brief sketch of one of them which we have given may be helpful to some who are interested in following the evidence.

RESEARCH DEFENCE SOCIETY.

WE have received the following appeal from the Officers of the Research Defence Society and have much pleasure in commending it to the notice of our readers.

To the Editors of "KNOWLEDGE."

SIRS,—It is said that the fifth year, in the life of any Society, is the critical period of its fortunes. The Research Defence Society was founded on January 27th, 1908. To all who are interested—and who is not?—in medical research, we beg you to let us say that the Society has its hands full of work, and only wants more money to do more work. Much has already been done, by lectures and by distribution of literature, to bring home to people the truth about experiments on animals in this country, and the great value of them, not only to mankind, but also to the animal world. The expenses of our Society are heavy; but the good results of our work are extended far and wide. We have lately opened a Bureau and Exhibition at 171, Piccadilly (opposite Burlington House). We are exhibiting pictures, portraits, charts, anaesthetics and inhalers, germs in pure culture, tsetse flies and mosquitoes, and so forth. This little exhibition, every day and all day long, displays to "the man in the street" the facts of the case. We are the only Society which is doing work of this kind; but, of course, it cannot be done without money. Our record for the last four years gives us the right to hope for a great increase of our Membership, and of our funds, in the coming year.

DAVID GILL, President.
F. M. SANDWITH, Hon. Treasurer.
STEPHEN PAGET, Hon. Secretary.

21, LADBROKE SQUARE, W.

THE INFLUENCE OF AGE ON THE VITALITY AND CHEMICAL COMPOSITION OF THE WHEAT BERRY.

By R. WHYMPER.

THE knowledge that the vitality of a living thing decreases with the passage of time is so imprinted in the human mind that all our life is spent, consciously or unconsciously, in prolonging the end which must come or in preparation against that time.

But the fact that there must be an end to all living things does not restrain but rather stimulates both our efforts in unravelling the mystery which surrounds the very existence of life and our imagination in regarding a thing which has possessed life even beyond the span of years allotted to man.

A tortoise of four hundred years is an object of respect, a giant oak of some one hundred and fifty years is venerable, and both by reason of their vitality command greater regard than a lifeless rock which has existed more or less of constant appearance and consistency since the world began.

With the passing of life, decay of the material sets in eventually: sooner if the organic matter is readily decomposable and under suitable conditions: later if the matter is more resistant or under conditions which tend to prevent the action of moisture, air and bacteria from having full play.

Thus animal remains rapidly decompose when exposed to air under ordinary conditions, though, as in the case of bodies carefully dried or specially treated with antiseptics, they may remain in a state of preservation for a considerable period of time.*

FIGURE 78.
Mummy Wheat, longitudinal section.

FIGURE 79.
Mummy Wheat, transverse section.

Vegetable matter containing much cellulose is obviously less liable to rapid decay than that containing easily fermentable components such as cooked starch and sugar; this can be readily seen in such cases as the bread and cake found in the tombs of the ancient Egyptians and which are now composed of little else than the husks of wheat and other cellular tissue.

It was the custom of the ancient Egyptians to provide their mummied dead with articles of use and personal property as well as with food such as bread, meat, wine, cakes and wheat, as means of refreshment during their trying journey to the world "beyond the sunset" and it is owing to this religious custom that we owe many of our most treasured ancient Egyptian relics. It is to be hoped that the food placed with the dead was found sufficiently sustaining to last over the long period of time which elapsed before the wandering soul again found rest in the body, and which, if Herodotus is to be believed, was about three thousand years, or at least that it was never failing in quantity like the "widow's cruse."

The quality of the food stuff, however, after the same lapse of time, leaves a good deal to be desired, though the wheat with which the present paper is chiefly concerned is remarkable for the few changes that have taken place within the berry.

* It may be of interest at this point to mention that I have in my possession a raw beef steak placed in "vacuo" in glass in 1889 and which to all appearance is in a remarkably good state of preservation. My uncle, the late Mr. Edward Whymper, and Mr. Hicks conducted a number of experiments with "vacua" in that year, chiefly in connection with the standardisation of aneroid barometers.

The beef steak in question was one of their many experiments and my uncle always displayed great interest in this unique object, which was found at his death in his bedroom at Teddington, where I remember it many years previously.

The following observation is attached to the glass vessel containing the meat, and, apart from the appearance of a few rose clustered crystals which have separated out, it is the only indication that the piece of steak is not fresh.

"*April 30th, 1904.*—This piece of Rump Steak was sealed up in "vacuo" on January 7th, 1889. Originally it occupied about four-fifths of the length of the tube. It has constantly shrunk, but it is only in the last few months that I have noticed the appearance of the fungoidal growth."

The meat now occupies less than one-tenth of the volume of the tube and the supposed fungoidal growth is in reality a crop of crystals.

FIGURE 80.
Wheat of the year 1852, longitudinal section.

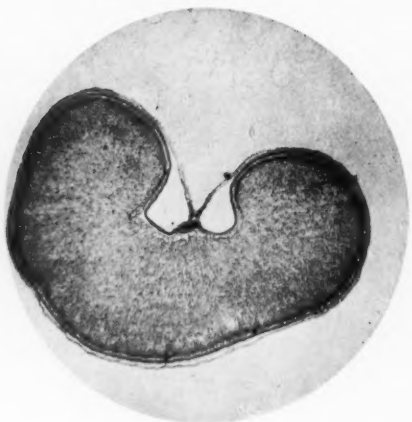


FIGURE 81.
Wheat of the year 1852, transverse section.

The most stable of the articles of food found in the ancient Egyptian tombs is wheat, and it would certainly add fuel to the fire of imagination, if from the wheat grains of a date somewhere about the time of the supremacy of Joseph in Egypt could be grown a crop of corn whose life had lain dormant for so many centuries.

In cases where authentic Mummy Wheat has been used, all attempts to secure germination have failed, though it will not be without interest briefly to review some of the failures and supposed successes in growing wheat and other seeds which were known to be of great antiquity, and to examine the possibility of the existence of life after so many ages.

The conditions which regulate the speed of germination can only be said to be indirectly connected with vitality since, in many cases, whilst germination is the exhibition of vitality, the causes which retard germination are purely physical characteristics of the seed.

Thus, certain seeds with thick impervious integuments, such as clover, which under favourable circumstances germinate within one or two weeks, may be found quite sound and dry internally though kept continuously wet on the outside for many years. In such cases it seems that a scratch is sufficient to cause almost immediate germination by allowing the moisture to penetrate the protective outer coating.

The appearance of strange plants in newly-turned earth removed from excavations, has been attributed to this power in seeds of lying dormant till, by the friction with the earth, the tough integument has been entered and the moisture allowed to reach the embryo.

The older the seed the lower is the probable vitality of that kind, and it is, of course, a well-known fact that the older seed, with the life still in it, requires greater coaxing to bring about germination, and that the plant resulting from it is more weakly in its growth.

In considering wheat, therefore, say three thousand years old, whilst it is certainly not impossible to imagine that it may, if kept for that time under ideal conditions, still be capable of germination, it is hardly to be expected that it should show signs of life, seeing that the conditions under which it has passed so many years in the Egyptian tombs, though good, were still such as would allow decay to set in, and a certain amount of air and damp to assist the decomposition.

The thickness and impenetrability of the outer husk or covering is the chief governing factor for the duration of vitality in seeds under equal conditions of environment.

According to the most recent researches* the power of germination of barley and wheat is but little affected during the first five years, but thereafter a rapid loss of vitality occurs and proceeds at an increasing rate till, in the tenth year, no living seeds remain.

FIGURE 82.
Wheat of the year 1853, longitudinal section.

FIGURE 83.
Wheat of the year 1853, transverse section.

* W. Carruthers, *Roy. Agric. Soc.*, 1911, p. 168.

The seeds under discussion were kept in paper bags in a drawer of the laboratory, and, therefore, may be presumed to have been subjected to fairly constant conditions of moisture and temperature.

Oats kept under similar conditions maintained their vitality for from five to seven years longer and, taken in conjunction with previous observations, may be said to supply the key to the results of the long list of experiments made by Carruthers. "The difference between wheat and barley on the one hand, and oats on the other, is the greater protection afforded to the embryo of the oats by the fact that in its case the glumes, which fall off as chaff in the wheat and barley, remain attached to the seed."

FIGURE 86.
Rivet Wheat, longitudinal section.

FIGURE 87.
Rivet Wheat, transverse section.

The cause which decides whether germination or death shall result in the embryo of a seed is the balance between heat and moisture.

Heat is, perhaps, the greater factor, if it is possible to speak so of two essentials, in deciding germination, whilst moisture may be said to govern vitality.

By this is meant that whilst moisture without heat, or heat without moisture, is incapable of producing germination, yet the heat optimum applied to a seed with a minimum of moisture, is more likely to produce germination than a maximum of moisture present with a minimum of heat. In the other case, moisture must be present in the embryo plant if life is to be retained, though air-dried seeds have been exposed for some days to a temperature very far below freezing point, or, again, to an upper limit of about 130°F without life becoming extinct.

It would perhaps be more correct to say that in the case of germination, the balance between heat and moisture is finer than when the death of the embryo within the seed alone has to be considered, when, though the loss of moisture beyond a certain point means death, the temperature to which the seed is subjected may be varied within very wide limits without appreciable loss of vitality.

In the case of genuine Mummy Wheat, that is wheat found in the tombs of Egyptian mummies of known antiquity, heat existed without the necessary moisture to bring about germination, and the gradual desiccation of the berries reduced the moisture content of the embryo below that with which life within the seed remained possible.

The same cause brought about the death of the seeds examined by Carruthers, who states that it was no "chemical alteration produced by temperature, but the steady loss of moisture going on continually at ordinary air temperature."

After life is extinct the changes which take place within the wheat grain are more chemical than bacteriological in the case of Mummy Wheat at any rate, for the presence of such powerful antiseptics as bitumen and essential oils (both of which are very apparent in the smell of the Egyptian Mummy Wheat here examined) is sufficient to prevent the action of moulds or bacteria.

The exact nature of these changes will be discussed more fully in a later section.

The Mummy Wheat

FIGURE 84.
Wheat of the year 1854, longitudinal section.

FIGURE 85.
Wheat of the year 1854, transverse section.

examined was found in a tomb at Deir-el-Bahari of an estimated date 1500 B.C., and, assuming that the harvest season of that date was a fair one, the berries probably contained some 12 per cent. of moisture when placed beside the dead. At the time of analysis about three thousand four hundred years later, it contained 10·69 per cent. of moisture and, in its passage across the sea from the very warm climate of Egypt to the comparatively moist atmosphere of England, it certainly picked up at least the odd 0·69 per cent. The loss of the 2 per cent. of moisture and its vitality are the only outstanding features which distinguish this most ancient wheat from that of the last season's harvest. The increase in acidity and loss of gluten strength, though pronounced, are comparatively insignificant and are due to the two main causes.

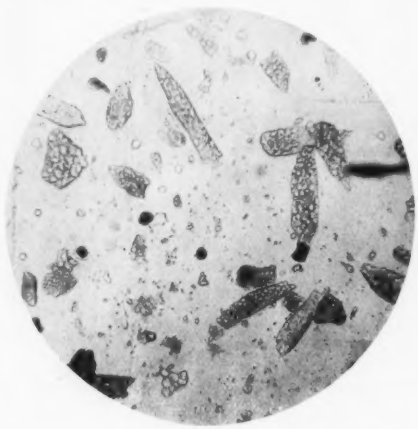


FIGURE 88.
Flour obtained from the Mummy Wheat.

In a previous paper* the writer has observed that under good conditions of germination about 35 per cent. of its weight of water is absorbed by the wheat berry, and it is conceivable that with a constant temperature such as is found in the subterranean tombs of the ancient Egyptians life might have been perpetuated within the berries by the continual existence of, say, another ten parts of water in every one hundred parts of the wheat, over that which was actually present, an additional quantity which would not have encouraged germination.

Under the existing heat and humidity conditions of the tomb the tendency of the wheat was to impart its moisture to the surrounding air, and thus the moisture content of the wheat was reduced below the minimum which was capable of supporting life for even beyond ten years, and the grains may be assumed to have lain for some three thousand four hundred years without the power of reproducing their kind.

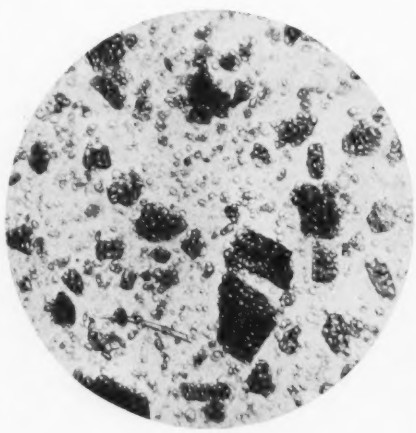


FIGURE 89.
Flour obtained from Rivet Wheat.

It is reasonable, therefore, that the wheats of such recent dates as 1852, 1853 and 1854 should show but little variation in chemical composition over their kind of last year's harvest. Indeed there are not sufficient chemical differences between all the samples of wheat analysed to show that the loss of that potent factor, Life, has taken place, nor even do the analyses show more divergent results than would be obtained from modern wheats of different varieties.

The experiments of Carruthers, already referred to, have for ever buried the alluring possibility of genuine Mummy Wheat reproducing its kind or even of a ten-year-old wheat from presuming to emulate the efforts of a new born: but it is probable that under the correct conditions which it is hoped will be found when the result of the experiments on hand are completed, and which, after all, are nothing more than rational, the vitality of wheat will be extended and the natural process of decay arrested till it is conceivable that dormant life may be prolonged beyond even the three thousand years which have passed over the head of the Mummy Wheat now under examination and of its accompanying and honoured dead, who by this time is, according to Egyptian belief, again the proud possessor of a soul, though probably exhibited under a glass case to the vulgar gaze of an inquisitive and unbelieving public.

PREVIOUS ATTEMPTS TO GERMINATE SEEDS OF ANCIENT ORIGIN.

It has already been pointed out that in different seeds the duration of vitality is very variable. Thus it is quite well authenticated that the seeds of the Nelumbo (water lily) have sprouted after having been kept dry in a herbarium or museum for one hundred and fifty years, whilst on the other hand the seeds of wheat have been shown by Carruthers in a paper already mentioned to have lost their vitality at the end of ten years when kept dry under normal conditions. Even among one class, such as the cereals, the duration of vitality in the seeds is very variable, as will be seen by Table 16 taken from Carruthers' paper:—

*VII. *Internat. Cong. App. Chem.*, 1909, and *Milling*, March 18th, 1911.

TABLE 16. PERCENTAGE OF SEED GERMINATED EACH YEAR.

Seed.	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911
Barley	99	99	98	95	90	77	25	?	19	—	—	—	—	—	—	—
White Wheat ...	100	97	92	94	?	88	75	?	29	—	—	—	—	—	—	—
Red Wheat ...	99	98	95	88	94	80	79	55	51	—	—	—	—	—	—	—
White Oats ...	100	99	99	99	98	99	99	95	97	69	57	49	12	0	—	—
Black Oats ...	97	97	96	94	90	98	92	94	95	88	76	68	34	32	2	—

Nor can this be taken as the last word on the subject, for the preservation of vitality is, of course, dependent upon a number of factors, the chief of which are :—

(*a*) The character of the season and the ripeness of the seed when harvested.

(*b*) The percentage of moisture in the seed.

(*c*) The place of storage.

The varying results of other experimenters on the duration of vitality among cereals confirm this statement, and to quote two instances :—Loudet, who made trials in 1856–7 with wheat of the years 1853–1856 inclusive, obtained the following results:—

Wheat of 1853, per cent of seeds germinated 0
„ „ 1854, „ „ „ „ „ 51
„ „ 1855, „ „ „ „ „ 73
„ „ 1856, „ „ „ „ „ 74

whilst Haberlandt, on the other hand, obtained results more comparable with Carruthers, thus :—

TABLE 17. PERCENTAGE OF SEEDS GERMINATED IN 1861 FROM THE YEARS—

	1850	1851	1854	1855	1857	1858	1859	1860
Wheat ...	0	0	8	4	73	60	84	96
Rye ...	0	0	0	0	0	0	48	100
Barley ...	0	0	24	0	48	33	92	89
Oats ...	60	?	56	48	72	32	80	96
Maize ...	0	?	76	56	?	77	100	97

Dealing with Mummy Wheat, which should be very much older than those just discussed, there have been many experimenters who are said to have succeeded in bringing about germination. Of these the most notorious is the Count Sternberg,* who (it is said) received the grains of wheat from a trustworthy traveller, being assured that they were taken from a sarcophagus. Two of these grains are supposed to have germinated, and though the majority of well-informed people must realize that there was some imposture, probably on the part of the Arabs, the belief in the existence of vitality in Mummy Wheat is still strong, owing to the publication of Count Sternberg's paper, and the constant repetition of his statement in non-scientific journals, that, even up to the present time, a very large number of people who do not study the probabilities is prepared to combat any statement to the contrary.

When the array of experimenters with Mummy Wheat, or wheat of even more recent date, is reviewed, and when it is realised that in almost every case of wheat over ten years old, germination does not result, the probability of Count Sternberg's success can be at once dismissed.

Vilmorin, Dietrich† and many others besides the present writer have attempted to grow genuine Mummy Wheat and always with the same negative results. Soaking in oil, as recommended by Count Sternberg, and nearly every means reputed to favour germination have been employed but without success, and the same methods applied to the wheat grains of the years 1852, 1853, and 1854, were equally unsuccessful. After proper exposure to moisture, the space that should be occupied by the germ has been found to be filled with a slimy putrefying liquid which was quickly covered by a crop of mould.

It is useless to describe the methods applied to the grains in order to induce germination, and it is proposed to enter at once upon the results of the chemical and microscopical examination to which they were subjected, and to draw from them such conclusions as may be of scientific and commercial value.

EXPERIMENTAL RESULTS.

The five wheats examined were as follow :—

Mummy Wheat, circ. 1500 B.C. The grains of this sample were dark rusty red in colour and fairly plump though the end containing the germ was shrivelled and wrinkled. Twenty-seven grains of an average sample of this wheat weighed one gramme (See Figures 78 and 79).

On crushing for chemical and microscopical examination the grains rapidly disintegrated and formed a very fine powder, so that it was with difficulty that a loss of the very light portions was prevented. The fine powder immediately after crushing was very irritating to the nostrils and smelt strongly of bitumen.

The grains are believed to be of Emmer wheat from the appearance amongst the sample of what seems to be a complete head of the wheat bearing only two grains.

Wheats of 1852, 1853, 1854, were all samples of White Wheat, that of the first two years showing medium plump grains (thirty-four to the

* Count Sternberg in the Journal, *Flora*, 1835, Page 4.

† Dietrich, Hoff. Jahr. 1862-3, Page 77.

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gramme). The last year's sample was particularly plump and numbered twenty-two grains to the gramme. (See Figures 80–85).

Wheat of 1911 was a sample of Rivet Wheat grown in Huntingdonshire of plump grains which numbered twenty to the gramme. (See Figures 86 and 87).

On treating the whole grain flour (crushed in the laboratory) with water, that from the Mummy Wheat produced a thin paste without any strength of dough whatever. The apparent stickiness and lack of elasticity led the writer to believe that a considerable amount of soluble dextrin and possibly sugar would be found. This assumption proved to be unfounded on analysis.

The flours from the wheats of 1852, 1853 and 1854 showed plenty of elasticity on doughing with water, and had not suffered apparently in "strength" through deterioration of their gluten by long storage.

The lack of a sufficiency of the sample of Mummy Wheat prevented any investigation into the state of its nitrogenous compounds, which, though still present in considerable proportions, had completely lost the physical characteristics of wheat gluten.

MICROSCOPICAL EXAMINATION.

In a previous paper, by means of transparent sections taken through the wheat berry, the writer was able to show the changes and direction of change taking place in the grain during germination. It was hoped that sections of the wheats here under examination, taken in a similar manner, would reveal certain structural changes which might be expected to have taken place during the passage of so many years. Examination, however, shows that the actual structure of the germ remains unchanged, and that only the coalescence of the minute cells has resulted. In the wheats of 1852, 1853, and 1854, the germ remains unaltered in appearance.

Closer examination of the endosperm of the Mummy Wheat reveals the decomposition of the cementing material which binds the bundles of starch together, and, consequently, the extreme friability of the wheat grains when crushed, and the lack of adhesiveness of the resulting flour when doughed, are accounted for. The actual starch grains are not affected in any way, and it may be assumed, therefore, that no diastase had penetrated into the endosperm as would occur on incipient germination.

As will be seen from the acidity figures of the ground berries there is no great increase in sourness in the wheat grains up to fifty years, but a very pronounced increase in the more ancient Mummy Wheat.

This fact is interesting in the light of Professor Bell's experiments with stored flours, made in 1907, and other experiments made in America in the two following years.

The general indication of these tests showed that the increase of acidity was more pronounced in the case of low-grade than high-grade flours, and was due chiefly to the action of acid-producing bacteria which have ready access to stored flour.

It was further proved that dampness was the prime factor which favoured the production of acidity, whilst temperature was of little or no account.

In normally air-dried wheats, sufficient moisture does not exist to produce acidity rapidly, and the protective covering of the husk is thick enough to stay for a considerable period the action of aërobic acid-producing bacteria.

As soon as the husk is capable of being penetrated by air, either from the slow growth of moulds and smaller fungi on the exterior of the grain or from chemical oxidation, the growth of the acid-producing bacteria within the berry is favoured.

It is of further interest to note that increase of acidity is accompanied by reduction of the gluten strength, a fact which has been noted by Wood and others who found that even N/1,000 solutions of hydrochloric acid and varying dilutions of other acids such as phosphoric, oxalic, acetic, lactic, citric and tartaric, were capable of producing degradation of the gluten and a corresponding reduction in the "strength" of the dough.

The most prominent feature of the microscopical examination of the flours produced from the wheats under discussion was the appearance of long, sharp-pointed angular pieces, into which the oldest wheat fell when crushed. (See Figure 88).

The shape of the particles is entirely different from those produced from normal wheat, or from the wheats up to fifty years of age. (See Figure 89).

This is accounted for by the decomposition of the binding proteid matter and by the cleavage which has taken place when the grain is crushed along the lines of the proteid matter which binds the bundles of starch granules, rather than along the non-proteid divisions which separate the starch-proteid groupings.

It is without doubt correct that in normally aged and dried wheat the first cleavage is along the lines of the parenchymatous cellulose, by means of which the endosperm is divided up into groups of starch granules embedded in gluten. These groups are, as a rule, angular and also four-sided, and are readily distinguishable from the sharp-pointed and tapering pieces into which the endosperm breaks up when the Mummy Wheat is crushed.

(To be continued.)

THE PROBLEM OF THE MOON'S ORIGIN.

By B. G. HARRISON, F.R.A.S., F.R.G.S.

(*Continued from page 74*).

The system consists of seven principal planets, besides our earth, in various stages of evolution, and rotating at different speeds, but the conditions affecting each one are so diverse from those of our own globe that no satisfactory analogy can be drawn. It is true that the rotations of Jupiter and Saturn are exceedingly rapid, but this is just what we should expect if the theory of planetary formation previously outlined is correct, since the larger planet would have a larger moment of momentum than would be derived from its extra mass alone, owing to the more rapid circulation of particles caused by greater gravitative force in its vortex during the planet's evolution.

Another objection to the fission theory of the Earth is the difficulty of understanding how it would be possible for a concrete mass the size of the Moon, torn away from the Earth by rapidity of rotation, to hold together under the disruptive strain imposed by the mutual attraction of the two bodies when in close proximity.

Thus it seems, so far as we are aware, that the origin of the lunar terrestrial system by capture offers none of the difficulties that we have to contend with in the fission theory, and if we accept the nebular hypothesis outlined earlier in this article, would seem the most natural and concordant way of accounting for the present position of the Moon.

Nevertheless, weighty though the objections are to the theory of the Moon ever having formed part of the Earth, our satellite offers a very remarkable piece of evidence in favour of this supposition.* This evidence consists in the action of tidal friction. The manner in which the Moon raises tides by differential attraction is too well known to require any explanation here. If no tidal friction existed, high water would always be on those parts of the Earth's surface directly under the Moon. As, however, water is not perfectly frictionless, the rotation of our globe carries these aqueous bulges to a point somewhat in advance of the Moon's orbital position, and they consequently act as a brake on terrestrial rotation. Since it is impossible for one body to retard another without a corresponding acceleration in its own motion, it follows that the energy lost by the Earth must be transmitted to the Moon. This has the effect of increasing its orbital force, and under the influence of centrifugal action driving it further away from us. As, however, this force is only tangential, and the action of recession involves motion against the more powerful pull of direct attraction, the actual orbital velocity is decreased, and the additional energy transmitted becomes entirely potential. Thus we see our day and lunar month both slowly increasing in length, although not at the same rate. Conversely, in earlier times both must have been shorter. If this decrease had been a measurable quantity in historic times, we should be able to detect it from the record of the early eclipses; for although it is necessary to have the utmost accuracy in the majority of astronomical observations if they are to be of any value, in this case the knowledge of the locality in which the eclipse was observed would to a great extent compensate for the lack of precision in the record of its actual time of occurrence. Yet it appears that there is no conclusive information to be obtained from this source, and its absence makes us feel certain that retardation of rotation must now be an exceedingly slow process. Nevertheless, this is no proof of its non-existence, and since the loss of energy by friction varies inversely as the sixth power of the distance, any reduction of the Moon's orbit would involve a vast increase in the retardation of our axial rotation.

It is possible, therefore, to imagine a time when our day was only half its present length, and to calculate, by deducting the energy which the Earth has since that time transmitted to the Moon, what the length of the month would have been at the same period. At the present time the rate of increase of the day is more rapid than that of the month, and, consequently, if we work *backwards*, we find the month shortening less rapidly than the day. This relative progression continues until a time is reached when there were twenty-nine days to the month, instead of 27·3 as at present. This is a maximum, and it has been mathematically demonstrated that there could never have been more than this number of days during one revolution of the Moon. Remote though this period must actually have been, it is yet comparatively recent when we consider the vast time necessary for the entire process required by this theory, and may be regarded as a crisis in our satellite's history. Before this epoch the month must have decreased more quickly than the day, and, still travelling backwards, we can trace the Moon in the course of ages moving ever faster in a huge spiral path. Rapidly, now, though the acceleration of the Earth's rotation must have proceeded, the Moon continued to gain upon it until eventually both were revolving together,

* The following theory is due to the researches of the late Sir George Darwin, F.R.S., from whose papers on the subject the figures and general particulars have been obtained.

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the Moon close to the Earth, and each permanently presenting the same face to the other. Now, when this period was reached, both day and month would have occupied some time between three and five hours. It has been previously mentioned that the speed of rotation necessary to render the Earth unstable, owing to centrifugal force, would be about two and three-quarter hours, so we have now arrived at an epoch when our planet would barely be able to hold together. It is assumed that the earth must at this time have been, if not actually in a molten condition, at least considerably more plastic than it is at present. Even now the tidal action of the Sun is shown by the difference between spring and neap tides, and the more plastic the condition of the Earth the more effective would this be. It is thought probable that when our globe was rotating at this speed the forced period of the tide would be in close agreement with its free period, which would have the effect of increasing the height of the solar tides sufficiently to render it quite possible for the Earth to break up under the combined strain, and thus give birth to the Moon.

The principal difficulty which confronts us is our inability to understand how it would be possible for the latter to hold together under the strain imposed upon it by the attraction of the Earth, and it is suggested that the Moon was thrown off as a flock of meteorites until it reached a sufficient distance to allow it to condense into one body. Nevertheless, this suggestion is not very satisfactory, since the meteorites would necessarily be at varying distances from the Earth, and so would be travelling at different velocities to preserve their equilibrium. This would have the effect of scattering them all round their orbit, and so tend to nullify their power of creating tidal friction. However, if this difficulty is put aside, the facts brought out by Sir G. H. Darwin's analysis are really remarkable, and it seems more than difficult to ascribe this wonderful coincidence to chance, especially as the eccentricity of the Moon's orbit and the obliquity of the ecliptic also harmonise with this theory. If the Moon originated in any other way the chances are enormously against the mutual reaction of the two bodies being exactly as we find them. To make this clearer let us assume the present position of the Moon and the length of our day to be unknown, but that we had evidence of our satellite having originated in the way just described; then, by calculating the force of tidal action, we should find that this would be just sufficient to have driven a body of the Moon's dimensions to a distance of two hundred and thirty-nine thousand miles, and reduced the rotation of the earth to its present period of twenty-three hours fifty-six minutes.

It is interesting to pursue this theory further, and try to penetrate our planet's future in the same way as we have endeavoured to trace its past history. For, if no lunar energy is being lost by motion against resistance, the length of the day must be increasing more rapidly than that of the month. Consequently, we foresee a time when our day is twice its present length, and the month containing only eighteen of these days. Mathematical analysis enables us to penetrate still further, until we reach a period when the day and month are again equal, but instead of being only four hours long, they extend to about fifty of our present days. There is also this difference that, whereas in the former case the Moon was revolving in a state of unstable equilibrium, in the latter it is dynamically stable. The time required before the two bodies can reach this condition is so vast that it passes human comprehension, and it is more than likely that some third factor will have interposed before the requisite period has elapsed. However, if the system is still behaving in its present orderly fashion, it is possible to forecast the final act in this drama. We have reached a time when the Earth and Moon are revolving as if bound together by steel bars, and consequently causing no tidal friction in each other.

Nevertheless, the action of the Sun will continue to affect the Earth, and the latter will consequently commence to rotate more slowly than the Moon revolves. This will cause a recurrence of tidal friction between the two bodies, but with this difference, that now the protuberance caused by the Moon will be behind it instead of in front. This will naturally have the opposite effect on the lunar orbit and will gradually draw the satellite back in ever decreasing spirals, accelerating the Earth's rotation in the process, until it finally returns to the surface of the latter. This time however there will be no chance of the Moon's rebirth, as the earth will have lost so much energy owing to solar friction that even in the event of the Moon having encountered no resistance in its celestial journey, and so being able to return the whole of the energy transmitted to it by the Earth, the latter's rate of rotation will still be slower than at its birth.

There is one more point to be considered, namely the movement of Phobos, the inner satellite of Mars. The motion of this satellite has frequently been advanced as a proof of the former rapid rotation of its planet, and so indirectly of the Earth.

It was discovered in 1877 by Professor Hall, and was found to revolve round its primary in seven hours thirty-nine minutes at a distance of less than four thousand miles from its surface. As the Martian day exceeds our own by more than half an hour this system appears to be absolutely unique, and its discovery electrified the whole astronomical world. It has been suggested, therefore, that this system has been evolved by fission, and has already reached its final stage with its day longer than its month; the rotation of Mars having been reduced to its present period by solar tidal friction. It is unlikely, however, that this can be the case, since the comparative weakness of the solar tides on the planet, and the exceedingly small orbital momentum of the satellite, present very considerable difficulties to the supposition. Moreover, the phenomenon can quite well be accounted for by the theory of capture in a

resisting medium, since owing to its minute size a proportion of its momentum would be more easily lost, and it might thus have been brought to its present position close to the planet by revolving against resistance. This suggestion gains weight from the fact that there are known to be over six hundred similar bodies to the two Martian satellites, revolving between that planet and Jupiter, and it seems quite likely that two of these asteroids may at some time have come within the sphere of the planet's influence and so have attained their present positions.

Apropos of these satellites, it is interesting to dwell for a moment on the remarkable verification of prophecy brought to light by their discovery. At the time when "Gulliver's Travels" was written a good deal of ridicule had been cast upon contemporary astronomical research, and for purposes of satire Dean Swift caused Gulliver to relate how, in the island of Laputa, astronomers had discovered two satellites to Mars, one of which revolved around him in ten and the other in twenty-one and a half hours. Forty years ago such a phenomenon would have been considered quite impossible and only a flight of the wildest imagination, and when it is considered that the laws of chance would be almost infinity to one against the fulfilment of the prophecy it renders its realisation all the more remarkable.

We will now briefly recapitulate the arguments for both hypotheses of lunar origin. The whole subject turns on the question of a resisting medium. If this still exists it would invalidate the calculations of the Moon's motion previously described, and would render the probability of its having been captured almost certain. This theory, indeed, appears to have no very great drawbacks attached to its acceptance, and, according to the supposed origin of the solar system, to be most concordant with it. Moreover, there is an outstanding inequality in the movement of the Moon which up to the present has defied the utmost efforts of astronomers to assign to any known cause, but which might be accounted for by the effects of orbital motion against resistance. Supporters of the fission theory, however, have to contend with many very real difficulties, amongst them to account for the Earth ever having had the necessary rotational velocity, and even if this is conceded, the difficulty of understanding how lunar disruption could be prevented until the Moon attained to a sufficient distance to revolve in safety. On the other hand there is the wonderful evidence in its favour just detailed and which, if it is a coincidence, must be regarded as one of the most extraordinary in the annals of astronomy. It must also be remembered that the ability of tidal friction to retard rotation is an established fact, as shown by the Moon's own rotation, the only doubtful factor being the *time* required to produce any effect.

Our satellite would gain an additional interest if the capture theory is ever proved to be correct, since there seems to be a greater fascination in scrutinising a world having an entirely different origin from our own, than in merely looking upon a fragment of our earth. Let us hope that some day the mystery may be cleared up, and that we may know more concerning the past history of our companion and nearest neighbour in the cosmos.

CORRESPONDENCE.

AN "IDEAL" MUSEUM AND ITS GUIDE.

To the Editors of "KNOWLEDGE."

SIRS,—The "Provincial Curator," in his contribution to "KNOWLEDGE" of January, does an unintentional injustice to the Trustees and Curator of the London Museum. The "Guide to Kensington Palace" is, apparently, a reprint of a former edition in which have been included some notes on the London Museum by the author, but these notes have no authority from, and were never submitted to, or revised by, those responsible for the London Museum and its arrangement. Your contributor has, perhaps, been misled by this "guide" into thinking that the series of objects are not chronologically arranged, but this is a mistake so far as the rather limited arrangement of the cases in their present temporary home will permit.

If your contributor would call again at the London Museum and ask for the Curator, or one of his assistants, he would have much pleasure in explaining to him the motive and system of arrangement and in receiving from him any suggestions for their improvement.

GUY FRANCIS LAKING, M.V.O., F.S.A.,
Keeper and Secretary.

THE LONDON MUSEUM,
KENSINGTON PALACE.

[Our Contributor "A Provincial Curator" did say (see "KNOWLEDGE" for January, page 16) that the Keeper and Secretary of the London Museum did not write the Guide, and now we learn that it was never even submitted to him. On the face of it, this behaviour seems to be foolish and discourteous as well as detrimental to the best interests both of the museum and of the author of the Guide, who, we think, should come forward and give some explanation.—EDS.]

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—In reply to Mr. H. Stanley Redgrove's letter in the February issue of "KNOWLEDGE," I may say that it is not necessary for me to see his book, nor for him to state in detail his argument for the real existence of the fourth and other dimensions. What he has already stated is quite enough, namely, that his argument is that the existence of one dimension implies that of a second, a second that of a third, a third that of a fourth, and so on. I have pointed out that experience—direct perception of some kind—is the only possible basis of our knowledge of what exists, and that this experience gives us the law that where there is one dimension there must be three, but that it gives us absolutely nothing else—nothing whatever to support an argument that the existence of one dimension implies that of a second, and so on.

JOHN JOHNSTON.

HENDON, N.W.

THE RECENT ERUPTIONS OF THE ASAMA-YAMA (JAPAN).

By CHARLES DAVISON, Sc.D., F.G.S.

THE eruption of the Usu-san in 1910, of which an account is given in "KNOWLEDGE" for May, 1912, was by no means of unusual violence, but was interesting from the extraordinary rise of a new mountain more than six hundred feet in height, with which the volcanic operations were closely connected. The Usu-san is situated in the northern island of Hokkaido. Some four hundred and fifty miles to the south-south-west of the Usu-san, near the centre of the main island of Japan, is another volcano, larger in size and much more violent and devastating in its outbursts. The Asama-yama is well known in Japan as the most active of all its volcanoes, and as the scene of an eruption which ranks as one of the greatest yet known to us. This took place in 1783, and, as is usually the case, was followed by a prolonged period of quiescence, which at last seems to be drawing to a close. Numerous explosions during the last few years, with a marked increase of frequency in 1911, tremors and local earthquakes in large numbers, and a gradual rise in the floor and the crater, these are all premonitory symptoms of a coming period of violent eruption, and possibly of disaster, at some epoch which may be close at hand, but can hardly be delayed for many years.

The Japanese Government is fortunately alive to the danger that awaits them. By the timely precautions of the police in the summer of 1910, the eruption of the Usu-san was attended by no loss of life. Very different was the fate of the dwellers on and around the Taal Volcano in Luzon in January, 1911. Here, the early signs of the coming eruption were neglected, no attempts were made to remove the inhabitants, with the result that eleven hundred lives were lost in a single night. A watch on the Asama-yama has already been set. On its south-western slope, a seismological observatory has been erected, every throb of the volcano is being recorded, and, under the guidance of Professor Omori, the able director of the Seismological Institute in Tokyo, the observers have learned to distinguish between the tremors resulting from the volcanic explosions and those which are unattended by visible efforts. Professor Omori has recently made three ascents of the mountain and has studied the detonations which have accompanied the explosions and the areas within which the ashes have been deposited. The results of his enquiries are contained in a valuable memoir,* of which a brief summary is given in the following pages.

From a photograph of a model.

FIGURE 90.
The Volcano, Asama-yama.

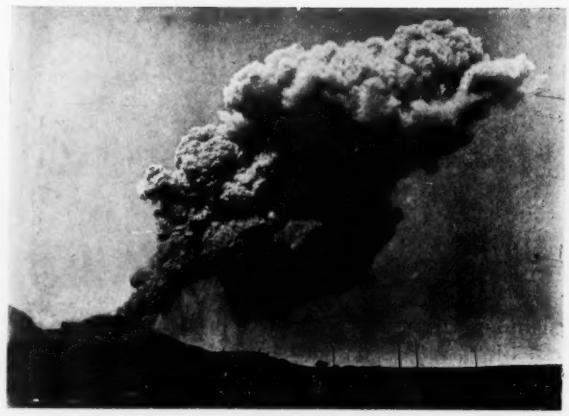

FIGURE 91.
The eruption of Asama-yama, May 8th, 1911.

The position of the Asama-yama is indicated by the small triangle in Figures 92 and 93. It rises from a plateau-region to a height of eight thousand one hundred feet above sea-level. As the height of its base is three thousand nine hundred feet on the north, and three thousand six hundred feet on the south side, the mountain proper is still more lofty than the present cone of Vesuvius. The crater is nearly four hundred feet in depth and about a quarter of a mile in diameter. The form of the mountain is shown in Figure 90, which is reproduced from a photograph of a model of the volcano, and in Figure 91, which represents the eruption that took place on May 8th, 1911. From Figure 90 it is evident that the present crater is surrounded on the west side (that is, to the left in the figure) by the remains of the wall of an old crater once about a mile in diameter.

* The eruptions and earthquakes of the Asama-yama: Bulletin of the Imperial Earthquake Investigation Committee (Tokyo), Vol. VI, 1912, pages 1–147.

The earliest known eruptions of the Asama-yama occurred in the years 685 and 1108. For this period of its history the chronicle is obviously incomplete. With the year 1527, the eruptions were renewed, and at the same time the record becomes less imperfect. The eruptions occurred in groups separated by intervals of repose. From 1527 to 1532 there were three eruptions, from 1596 to 1605 four, from 1644 to 1669 twenty, from 1704 to 1733 sixteen, from 1754 to 1783 five, and from 1803 to 1889 there were nine eruptions.

Of these fifty-nine eruptions, the greatest was that which occurred in 1783, the year of the great Calabrian earthquakes. This eruption, which lasted altogether for eighty-eight days, began on May 9th. For some time it consisted mainly of loud detonations, occasionally accompanied by strong explosions. But these were by no means continuous, there being intervals of quiet, one of which lasted for nearly three weeks. On June 28th, the explosions became more violent. A month later, ashes fell in Yedo (now Tokyo, eighty-five miles distant), where the people, not knowing the cause, wondered why houses and doors were shaken while the ground remained quiet. On August 2nd, the violence of the explosions reached its maximum, large quantities of red-hot stones and sand were projected from the crater. On the 4th, the rain of ashes was so dense that, even in distant towns, lanterns were used during the daytime in the streets. The next day, the eruption attained its climax. In the morning, after many violent explosions, a huge mass of molten lava and hot mud broke through the north wall of the crater and flowed rapidly down the northern flank of the volcano. This lava, after the lapse of more than a century, is still fresh in appearance; there are few signs of weathering, no vegetation covers it, and the rock still preserves the fantastic shapes into which it was thrown at the time. The total volume of this lava is about one-fourteenth of a cubic mile, or thirty times that of the present crater of the Asama-yama.

The lava-stream, however, stopped short of the villages, and, therefore, caused no loss of life or property. The great torrent of volcanic mud was more destructive. Descending with a velocity, which at first was not less than sixty miles an hour, it swept down the ravines and overwhelmed the villages along its course, the loss of life rising as high as eighty per cent. of their inhabitants, and amounting altogether to that of one thousand one hundred and sixty-two persons.

Professor Omori estimates that the district covered by the ashes is about one hundred and forty miles in length, sixty-two miles in width, and not less than four hundred and twenty-five square miles in area. As the layer of ashes was five or six inches deep at a distance of thirty miles, diminishing to one inch at Tokyo, the total volume of the ashes ejected, quite apart from that of the lava and volcanic mud, must have amounted to one-sixth of a cubic mile, or at least sixty times the volume of the present crater.

The disastrous effects of this eruption are connected by Professor Omori with the long period of quiescence which preceded it. For fifty years previously, the calm was broken only by a few small explosions. During the last two or three years of this period, smoke entirely ceased to issue from the crater, the floor of which was gradually raised almost to the level of the crater rim. It was due to the shallowness of the crater in its final stage that the immense mass of lava and volcanic mud broke through the containing wall and flooded the surrounding country.

For more than a century after this great outburst the Asama-yama remained almost undisturbed. In 1803, there were three slight eruptions, followed by others in the years 1815, 1866, 1869, 1875, 1879, and 1889, altogether nine eruptions, none of much account. Since the latter year, however, they have greatly increased in frequency. In 1894, six eruptions took place; in 1899, four; in 1900, seven; in 1901, six; in 1902-1907, six more; in 1908, five; in 1909, seven; and in 1910, ten. In the following year, 1911, there were no fewer than forty eruptions, all but three within the first four months of the year. In these estimates, minor detonations and explosions are omitted. Of the sixty-two eruptions during the four years 1908-1911, there were four of considerable strength, namely, those of May 31st and December 7th, 1909, December 2nd, 1910, and May 8th, 1911. The appearance of the mountain on the last of these occasions is shown in Figure 91. The characteristic features of these eruptions will be referred to later.

After the eruption of 1783, the crater of the Asama-yama was probably very deep and its diameter less than at present. The first attempt to measure its depth was made by Professor Milne in 1887. A rope was stretched across the crater. On this a pulley was run out with another rope that could be lowered vertically, supplied with thermometers at the end. When these had been lowered seven hundred and thirty-five feet, thermometers and rope were burnt, showing that the base of the crater had been reached. In June, 1911, Professor Omori made another attempt to sound the crater. On this occasion, but little smoke issued from the floor of the crater, and it was possible to see when it was reached by the heavy weight lowered from a part of the crater rim where the wall was vertical. The depth was found to be about three hundred and fifty feet, and this result was confirmed by measurements made with a theodolite. Thus, in twenty-four years, the floor of the crater has risen about three hundred and eighty feet, so that, after the lapse of another such period, if the rate of elevation should continue uniform, the floor will be brought up level with the margin of the crater.

During the first two months of 1911, seismographic observations were made at a temporary station at Ashino-taira, on the south-west flank of the mountain, at a height of six thousand three hundred feet above sea-level. From January 9th to February 28th, thirty-nine earthquakes were registered. All of

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them were extremely slight, only six being sensible without instrumental aid. According to Professor Omori, they belong to two types of movement. In one, the shock consists only of minute quick vibrations; in the other, it begins with slow movements, mingled after a few seconds with quick vibrations. The shocks of the first type originate at a depth of two or three miles below the base of the volcano; the vibrations resemble those of ordinary small local earthquakes, and they are probably due to the formation of fissures caused by the underground expansive force. The earthquakes of the second type were invariably the results of volcanic explosions. They began with a preliminary tremor lasting about two and a half seconds, which Professor Omori regards as due to the disturbances occurring just before the actual explosion, such as the formation or extension of an underground crack. The slow vibrations, which follow the tremor, are probably of "the nature of a bodily oscillation and due to the first bulging up and the consequent outward forcing of the mountain mass at the moment of the explosion."

The detailed study of the eruptions of the last few years has led Professor Omori to some interesting conclusions. Among the most valuable are those which relate to the propagation of the detonations resulting from the more important explosions. These have been heard at places on the east coast at a distance as great as one hundred and eighty miles from the volcano, and no doubt would have been

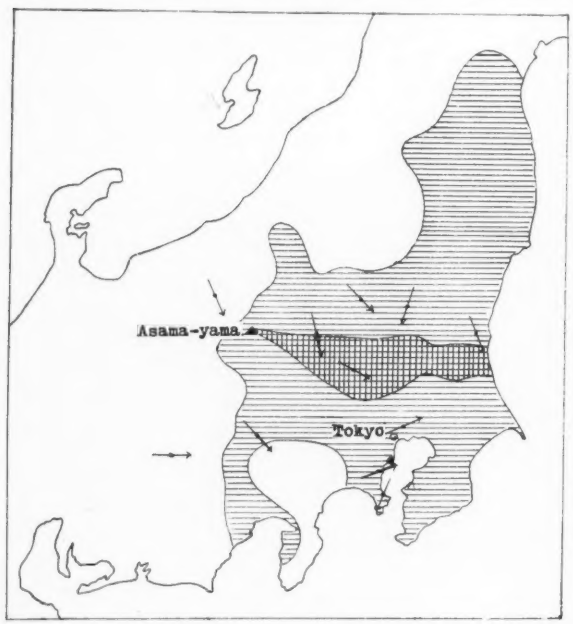

FIGURE 92.
The sound of the eruption of Asama-yama on December 7th, 1909, was heard on the lightly-shaded area, ashes fell on the darkly-shaded region.

heard farther if there had been land in this direction. There are some curious anomalies in the forms of the areas over which the detonations were audible. In most cases, the area is of the form indicated by the lightly shaded portion in Figure 92, which represents the region throughout which the sound of the

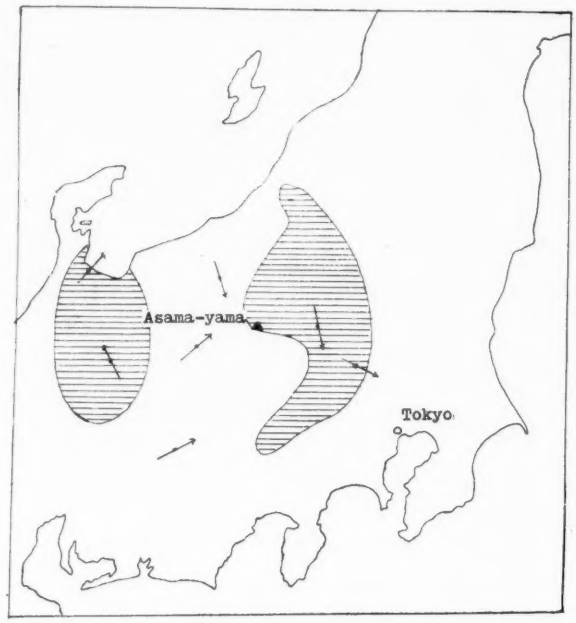

FIGURE 93.
The shaded portions show the two areas in which the sound of the eruption of Asama-yama was heard on December 25th, 1910.

eruption of December 7th, 1909, was heard. In Tokyo (eighty-five miles from the volcano), the detonation was loud and like that caused by a powder explosion, shaking the houses strongly, although there was no movement of the ground. The sound was heard at a distance of one hundred and ten miles to the south, and one hundred and seventy miles towards the north-east. Towards the west, however, the sound-area extended but a short distance, for the detonation was inaudible at places only fifteen miles to the west, and twenty-five miles to the north-west of the mountain. The darkly shaded area represents that within which ashes were precipitated. It is a lens-like zone, about one hundred and twenty miles in length, extending from the Asama-yama in a direction a little south of east. The arrows show the direction of the surface wind at the time of the eruption. In some cases, this agrees roughly with the principal direction in which sound and ashes were carried; in others, it is almost at right angles to this direction. The ashes, moreover, travelled at the rate of about fifty miles an hour, while the velocity of the surface wind was generally less than twelve miles an hour. It will be noticed, also, that the area of ash-precipation is roughly symmetrical with respect to the sound-area. It is, therefore, clear that the sound and ashes were carried by the upper winds, which appear to have a fairly uniform direction for the greater part of the year between east-north-east and east-south-east, tending as a rule in the latter direction. The height

of the carrying currents Professor Omori estimates at about five or six miles, this being the height generally reached by the smoke-column during the explosions of the Asama-yama.

In two cases, the form of the sound-area is still more remarkable, for it consists of two detached portions. The shaded areas in Figure 93, represent these portions for the eruption of December 25th, 1910. One portion includes the Asama-yama near its western margin, the other lies about fifty or sixty miles to the west. It will be noticed that the direction of the surface-wind was north-west in the eastern portion, and south-west in part of the other, so that there is no connection between the form of the sound-area and the direction of the surface-wind. Here, again, the anomalous form of the area must therefore be connected in some way with the trend of the upper winds.

A somewhat similar anomaly was observed in the audibility of the minute-guns which were fired from battleships lined at Spithead, when the body of her late Majesty Queen Victoria was borne from Cowes to Portsmouth. At places in the immediate neighbourhood of Spithead, and as far as fifty miles from it, the guns were almost or quite inaudible. From sixty to eighty or ninety miles they were clearly heard, so clearly that at a distance of eighty-four miles, labourers in the fields put down their spades and listened. Beyond ninety miles, records were less numerous, but one came from near Woodbridge, in Suffolk, at a distance of one hundred and thirty-nine miles, the regularity of the booms of the minute-guns allowing no doubt as to the observation.*

In the neighbourhood of Spithead and Portsmouth, the wind at the time was from the west or north-west, or "offshore"; at the great distances at which the sound was heard the wind was southerly. Since the velocity of the wind increases, as a rule, with the height above the ground, it follows that, in the direction from which the wind is coming the sound-rays are bent upwards, and pass over the heads of observers at a moderate distance. In the opposite direction, they are bent downwards, so that sound-rays which started upwards at a moderate angle are brought down again to observers at a considerable distance. Thus, the sound-rays were first of all refracted by contrary winds over the heads of observers between ten and fifty miles, and were afterwards brought down by favourable upper currents so that the reports were clearly audible from sixty to more than a hundred miles from Spithead. It is probable that a similar explanation may be given of the two detached portions of the sound-area in the case of the explosions of the Asama-yama.

*On the audibility of the minute-guns fired at Spithead on February 1st [1901]: "KNOWLEDGE," Volume XXIV, 1901, Pages 124-125.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

THE OCCULTATION OF THE STAR MAYER 588 BY JUPITER'S THIRD SATELLITE, GANYMEDE, 1911, AUGUST 13TH.—This very rare phenomenon was predicted by Herr Banachiewicz, and observed at several stations in South America, Professor Ristenpart having circulated requests to observers with a view to deducing the dimensions of Ganymede. Thirty-two had volunteered to help, who were spread over thirty-seven degrees of latitude, from Arequipa, S. 16°, to Punta Arenas, S. 53°. Several observers noted that the disappearance and reappearance were sharply defined, and could be accurately timed. The time intervals give chords of the disc of Ganymede in various latitudes, and the surprising fact emerges that it must be considerably larger than was hitherto supposed. The observations are best satisfied by an elliptical outline, with equatorial radius two thousand three hundred and thirty-one miles, polar radius two thousand one hundred and thirty-one miles. Dr. Ristenpart does not, however, attach great weight to the ellipticity. Ganymede would appear to be as large as Mars, whereas former estimates made it only equal to Mercury. One puzzle that the new result affords is the very low density that it implies. The mass of Ganymede is one thirty-ninth of the Earth, or one quarter of Mars, so if its size is equal to Mars its density is only one quarter as great, or, roughly, the density of water. It is true that the density of Saturn is still less, 0·7 of water, but the visible globe of Saturn is believed to be largely vaporous, which is unlikely to be the case with Ganymede.

THE SPECTROSCOPIC BINARY 9 CAMELOPARDALIS.—Several observers have noted abnormal behaviour of the calcium lines in the case of spectroscopic binaries. For example, Hartmann in the case of δ Orionis, Daniel, Schlesinger, Duncan and Slipher in the case of β Scorpii, find that the H and K lines of calcium do not share in the large displacement of the other lines, though they have probably a small displacement of their own. The suggested explanation is that the calcium vapour is not in the stars, but surrounds them as a cloud. Mr. O. J. Lee, at Professor Frost's suggestion, selected 9 Camelop. as a suitable star for further investigation of this question (*Astrophysical Journal*, January). Its declination is 60° North, and it culminates at midnight in December, so that very long series of photographs can be taken. Further, the H, K lines are strong and well defined. He deduces that the period of oscillation of the calcium lines is the same as that of the other lines viz., eight days, but the amount of oscillation less. He concludes that the calcium vapour forms an ellipsoidal sheath round the principal star, and that the spectroscopically effective regions are near the zero velocity points. He deduces for the joint mass of the system only one four-hundredth of that of the Sun, or two and a half times that of Jupiter. This seems an improbably small mass for so distant a body (its parallax is given as $''\cdot026$, implying a distance of one hundred and twenty light years), but the author admits that some of his assumptions are tentative. In any case, the existence of external calcium clouds in the case of several spectroscopic binaries has been rendered highly probable.

A MEASURE OF SOLAR RADIATION FROM FREE BALLOONS.—The same publication contains an account by Professor Very of an interesting research: the service that

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free balloons have rendered to meteorology in giving records of temperature, and so on, at heights inaccessible to man. They have now been used to carry a Crova actinograph, and so obtain a measure of solar radiation in a region where atmospheric absorption is greatly diminished. He gives the following determinations of the solar constant in calories per square centimetre per minute at different heights:—

1·5 calories at sea-level (winter).
2·00 „ at 4,420 metres (Keeler, Mount Whitney).
2·86 „ in the isothermal layer at 13,700 metres.

He concludes that the true value is 3·5 when there is no atmospheric absorption.

It is considered by some authorities that the solar constant may itself vary by quite appreciable amounts, independently of the action of our atmosphere. Professor Abbott suggested simultaneous observations at distant stations to test this. If they frequently varied together, the cause would probably be in the sun itself, not in our atmosphere. I believe that such a comparison is now being carried out between stations in Africa and North America.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

STRENGTH OF TENDRILS.—It has long been known that after a tendril has grasped a support it becomes much stronger and produces increased hard tissue; but the details have not hitherto been worked out satisfactorily. In an interesting paper, Brush (*Bot. Gaz.*, June, 1912) states that passion-flower tendrils exposed to tension, and having also formed contact with a support, had a much higher breaking strength (over one thousand grammes) as compared with tendrils in contact only (six hundred and fifty grammes) and free tendrils (one hundred and ninety grammes). Tension increases strength of tendrils sometimes by as much as fifty per cent. in the middle third of its length. By radial pressure, obtained by means of a mercury column in a rubber tube enclosed by the tendril, an increased breaking strength was obtained (nine hundred and ninety as compared with seven hundred and thirty grammes). The breaking strength of the tendrils was found to be increased by contact, pressure, and tension. As regards the internal structure it was found that the wood cells are increased both in number and thickness as the result of contact, and that the walls of the pith cells are thickened in consequence of tension. Just how contact, tension, and pressure act as stimuli it is difficult to say, but it is probably by bringing about increased hydrostatic pressure.

LUMINOUS BACTERIA AND FUNGI.—Professor H. Molisch has revised and enlarged his well-known work on luminosity in plants ("Leuchtende Pflanzen"; Gustav Fischer, Jena, M. 7.50). Since the publication of the first edition, eight years ago, various writers, notably Professor Molisch himself, have contributed to the knowledge of luminous phenomena in plants. Many of the cases of so-called luminosity in plants are due merely to reflection of light which is brought to a focus by lens-shaped cells, or are brought about by iridescence or by the presence of fluorescent substances; but real phosphorescence—the emission of light when the plant is placed in total darkness—is found in certain bacteria and fungi. By isolating the bacteria which cause the phosphorescence of meat and fish (*Bacterium phosphoreum*, *Bacillus phosphoreus*, and so on), and cultivating them in nutrient jelly in tubes and flasks, Molisch obtained a "bacterial lamp" with which he obtained some excellent photographs, some of which are reproduced as illustrations in his memoir. This "living lantern" can be used for a photographic dark-room or as a night light, since the light is strong enough to enable one to read a watch or to make out large print quite readily. The light is steady and lasts for several weeks, its intensity being about one candle-power per thousand square yards of the gelatine plate culture. It appears probable that the phosphorescence of these bacteria is due to the production by the bacterial cells of a phosphorus-containing organic compound ("photogen") of a proteid or phosphatid nature, which in the presence of oxygen and water undergoes slow oxidation—probably by means of an oxidising ferment (oxidase). The light dies out if oxygen is withdrawn from the culture or if the bacteria are dried, and reappears on admitting oxygen and moistening the culture again. The author discusses the cases of luminosity that have been described in various flowering plants; for instance, on sultry nights light is occasionally emitted by flowers, but this is either an electrical phenomenon comparable with "St. Elmo's fire"—a faint glow seen at the tips of masts and trees in thundery weather, and due to the dissipation of atmospheric electricity in the form of a brush discharge—or it is attributable to the presence of small phosphorescent insects which had been overlooked by earlier writers on "luminous flowers."

HETEROSTYLED FLOWERS.—In a considerable number of plants there occur long-styled and short-styled flowers, as in the Primrose and other species of *Primula*, and in some cases (as in the Purple Loosestrife) there may even be three forms of flower with three lengths of stamen and style. There is an interesting relation between the size of the pollen grains and the length of the stigmatic hairs in these flowers, the rule being that the longer the stamen the larger are the pollen-grains, and the longer the style the longer are the receptive hairs on its surface. Heterostyly raises several interesting problems in heredity as well as in floral mechanism, and Stevens (*Bot. Gaz.*, April, 1912) has investigated the development of the pollen and the other points in the life history of two heterostyled plants—Buckwheat and *Houstonia coerulea*. He found that in eighteen hours after "legitimate" pollination (pollination of long-styled with short-styled) an embryo began to develop, while in three days after "illegitimate" pollination (pollination of short-styled with short-styled or long-styled with long-styled) the pollen-tubes had not reached the egg. Under natural conditions, therefore, there would be very little chance of illegitimate pollination resulting in fertilisation. The author gives various details of the cytology and embryology in the two plants he investigated. He found that in the development of the pollen-grains the chromosomes in the reduction division are about twice as large in the short-styled form, and that in the long-styled form also the central chromosome is considerably larger in one daughter-nucleus than its mate in the sister nucleus. He compares this with the "accessory chromosome" which is regarded as being the "sex determinant" in the evelopment of the male germ-cells of certain insects.

GERMINATION OF ORCHIDS.—Some interesting observations have recently been made on the fungi which are associated with the roots of many orchids, forming a "mycorhiza" or symbiotic (mutually beneficial partnership) association between the fungus and the orchid. Burgeff and Bernard have shewn that the seeds of various tropical orchids will only germinate if the right micro-organisms are present. By isolating and cultivating the spores or the "spawn" (mycelium) of these fungi, pure cultures of the appropriate mycelium can be made and used for mixing with the sphagnum and fern compost in which the seeds are grown, the seed-pans and the rain-water used for watering are sterilised, and successful sowings are thus ensured.

XEROPHILOUS ADAPTATIONS IN MOSSES.—Grebe has published (*Hedwigia*, Band 52, 1912), a useful summary of the adaptations of mosses for protection against drought. He limits the use of the term "xerophyte" to those mosses which grow in situations where they are exposed to fairly prolonged periods of drought, are dependent upon atmospheric moisture, and are not protected against drought by other factors of the environment such as shade and damp atmosphere. Warnstorf regards dependence on atmospheric moisture, as opposed to that of the soil, as the chief criterion of xerophily in mosses, but Grebe points out that various mosses in shaded woods grow on tree trunks and yet are not xerophilous, being protected against drought-periods by their shaded and humid habitat. Many of the mosses of

shaded woods, however, are more or less xerophilous in structure, and grow high up on trees, whose crowns admit a good deal of light. In general, xerophilous mosses are so constructed that they rapidly absorb rain-water and dew, and retain it for long, once it is absorbed.

The majority of xerophilous mosses grow on rocks and trees. They occur from the coast up to the high Alps, the Grimmias and Andreaeas being the last representatives of the cryptogamic vegetation seen in ascending the highest hills. The effect of a dry continental climate is seen in general scarcity of mosses rather than an increase in the proportion of xerophilous species. The author then indicates the chief adaptations shown by mosses for retaining moisture or reducing transpiration. The chief xerophilous adaptations of this kind in the sporogonium are absence or shortness of the seta, causing the capsule to be sessile, or nearly so, and therefore enveloped by the upper leaves of the moss-plant; downward curvature of the seta, causing the young capsule to be plunged among the leaves — later the seta becomes erect for spore-dispersal; the presence of warty outgrowths or papillae on the seta; the presence of a large calyptra in some mosses covering the entire capsule; the hair-clad type of calyptra seen in the Polytrichaceae and Orthotrichaceae; the sheltered position of the stomata, especially in species of *Orthotrichum* with furrowed capsules and the stomata in the furrows, or in *Polytrichum* with stomata in the deep ring-like groove between capsule and apophysis.

The moss-plant itself, or gametophyte, naturally shows a far wider range of xerophilous or drought-resisting characters. These adaptations include, above all, perhaps, the cushion-like habit, the plants being aggregated to form a spongy mass, which holds water by capillarity; hyaline hair-points on the tips of the leaves; reduction in breadth of the leaf-blade, and corresponding increase of the cylindrical midrib; leaves more or less hollowed out or rolled up, undulate, wrinkled, or folded—all these arrangements providing cavities for the retention of water by capillarity; sheathing leaf-bases, as in *Polytrichum*; papillae and mammillae (solid and hollow outgrowths respectively of the leaf-cells); presence of water-storing tissue in the leaf; thick-walled leaf-cells; increase in number of layers of the lamina to two or more; strengthening of the leaf-margin; development of plate-like outgrowths or lamellae on the upper side of the leaf; presence of filamentous outgrowths (paraphylls) and dense covering of rhizoids on the stem; hygroscopic movements of the leaves.

ALPINE MOSSES AND LIVERWORTS.—Apart from the familiar moss-carpet of woods, and the bogs largely made up of bog-mosses (species of *Sphagnum*), and the woolly fringe-moss (*Rhacomitrium*) on moorlands, various mosses and liverworts play an important part in the vegetation of certain areas, chiefly in alpine districts.

Under the title "*Anthelia*: an alpine-arctic plant association," Dr. W. G. Smith (*Scottish Botanical Review*, April, 1912) gives an interesting account of a plant association which is characteristic of the higher Alps, and which was noted on Ben Lawers during the international phyto-geographical tour of this country last summer. This association is of special interest as one in which several liverworts and mosses play the part of pioneers in colonising a substratum which owes its origin in the first place to topography, and in the second to the action of running water. Towards the summit, where the grassy turf becomes more limited, and the most conspicuous vegetation consists of the woolly fringe-moss, sedges, and other mat-forming plants, there occur dark patches, represented on the summit ridge by larger tracts of almost black mossy crust. These patches and tracts are known to Swiss botanists, two of whom were with the party and pointed them out, as "Schneetälchen," which may be translated as "snow-flushes."

The formation of these "snow-flushes" has been traced in Switzerland and Tyrol, where the rocks and soil, uncovered by the melting snow, are often covered with flowers, while the snow still lies a few yards away. As melting proceeds the snow-water soaks through the turf, forming a system of temporary watercourses in troughs of undulating ground, and along the foot of slopes and escarpments, while the rain-water in summer tends to follow the same course. On gentle slopes or flats and in depressions, the force of the flow is not sufficient to carve out channels, as happens on steep slopes, but the water wanders slowly through the turf and deposits accumulated suspended matter as a sediment. The snow-water carries the dust it gathers on lying snow, mineral particles, and plant fragments, and collects other materials in trickling over the surface; snow-dust may contain fifty per cent. of organic matter, and as this with the mineral matter is laid down among remains of last year's vegetation, a rich soil is built up.

The vegetation of the snow-flush begins with flowerless plants, and these may remain as the dominant vegetation. Apparently the pioneer plant is the liverwort *Anthelia*, not only on Ben Lawers and other Scottish mountains, but also in the Alps, Scandinavia and Spitzbergen. This liverwort lies close to the surface, and in the fresh, moist state forms a bluish-green carpet, but in summer is often dry and dark brown or almost black; it is often coated with the threads of a fungus, and these occur also in the rooting-hairs of the liverwort—doubtless forming a mycorhiza or mutually beneficial partnership between the two plants. Alpine species of the moss-genus *Polytrichum* also occur in the snow-flushes; these mosses can withstand periodical submergence, and soon grow through the shallow deposits of sediment laid down, so helping to bind these deposits into a humous turf, while their close, compact growth also enables the tufts to withstand periods of drought. The snow-flush is an open association into which species of flowering plants from neighbouring plant communities migrate—Dr. Smith gives lists showing that several of these species are identical with those found in snow-flushes in the Alps.

On collating the accounts given by different observers, so as to obtain an outline of the evolution of the snow-flush vegetation, we find that *Anthelia*, probably preceded by algae and other lower organisms, forms a humous turf; *Polytrichum* follows later, and more or less takes the place of *Anthelia*; later still, *Salix herbacea* or *Alchemilla* assumes chief place, and so on. The successive stages of vegetation probably indicate stages in the evolution of the habitat, since the later vegetation will tend to give it increased stability; in time the accumulation of sediment, humus, and vegetation may be such that the snow-water is diverted to new situations, where the sequence will begin over again; and during the various phases other species secure a footing, and flourish well or ill according as the habitat suits them. The snow-flush is, therefore, a series of migratory associations. Crampton, whose important paper on the vegetation of Caithness was recently summarised in these columns ("KNOWLEDGE," May, 1912, p. 187), has defined such formations as follows (*Scottish Botanical Review*, 1912): "Migratory formations are of comparatively short persistence on the same habitat, which sooner or later undergoes change or destruction, with renewal elsewhere. Their associations tend to rapid degeneration from plant invasion. All stages of progressive successions are encountered."

AIR-CHAMBERS IN LIVERWORT THALLUS.—The Marchantiales, doubtless owing to the common occurrence of the familiar *Marchantia* and *Lunularia* on the soil in flower-pots, garden paths, and so on, and *Fegatella* beside streams, are often taken as typical of the Liverworts (Hepaticae), though in reality they form a relatively small division of that group, the majority of Hepaticae being differentiated into slender stem and thin leaves. At any rate, the thalloid Hepaticae are usually selected by teachers of Botany as being the typical forms, and *Marchantia polymorpha* is one of the most frequently studied of plant types. As so often happens, even the most familiar types repay renewed investigation by those willing to take the trouble and to remain unbiassed by the oft-repeated descriptions copied from text-book into text-book.

The air-chambers which occupy the upper portion of the tissue in the thallus of the Marchantiales, each chamber, in typical cases, opening to the atmosphere by a pore in the centre of its one-layered roof, were described by Leitgeb in

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1879 and 1881 as arising in the same way as the cavities in which the sexual organs (antheridia and archegonia) are sunken, namely, by upgrowth of the surrounding tissue of the thallus. In the simplest case (seen in most species of *Riccia*), the chambers are simply deep vertical canals, believed by Leitgeb to arise as the result of upgrowth of the superficial cells of the thallus as filaments, each filament being in contact with its neighbours at certain points so as to bound these air-canals. In the majority of Marchantiales, however, the chambers become widened out as the thallus grows, and are roofed over, the roofing layer arising, according to Leitgeb, by lateral outgrowth of the uppermost cells of the vertical plates that form the side-walls of the chambers; while in some cases the originally simple chamber is partitioned up by secondary plate-like ingrowths.

In 1907, Barnes and Land (*Bot. Gazette*, XLIV.) examined a number of Marchantiales, and claimed that in all cases the chambers arise by splitting between internal cells of the thallus, in exactly the same way as the intercellular air-spaces in the leaves, and so on, of the higher plants.

Pietsch (*Flora*, Band 103) has published the results of his careful investigation of the *Riccia* thallus, the chief species dealt with being *R. glauca* and *R. fluitans*. He has followed in detail the segmentation of the initial cells at the growing-point and the origin of the air-chambers, which in *R. fluitans* are wide and covered by a roofing-layer in which a pore may or may not be present. His descriptions and figures leave little doubt that Barnes and Land are right in their interpretation of the mode of origin of the chambers; but it may be added that Leitgeb's own figures are, as is usual in his work, extraordinarily accurate considering that he had not the advantages of modern microtome technique at command, and that it was simply in the interpretation of what he saw that he erred in this instance. Indeed, even after the publication of the paper by Barnes and Land, it appeared to the present writer, from examination of slides similar to theirs, that Leitgeb's interpretation might still be the correct one. in the case of *Riccia glauca* at any rate. However, the elaborate work of Pietsch appears to settle the question definitely. As this author points out, the view put forward by Barnes and Land that each chamber in the Marchantiaceae arises from a single primary cell (" mother-cell ") can hardly be accepted, for according to their description and diagram the vertical septa between neighbouring chambers would be two cells thick, while as a matter of fact these partitions are but one layer in thickness.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON.), F.I.C.

LUMINESCENCE ANALYSIS.—In Lehmann's fluorescence microscope, which is used with ultra-violet light, there is a special screen to protect the eye from injury. A description of this instrument and of the uses to which it may be put in analysis is given by Dr. O. Wolff in the *Chem. Zeit.* (1912, XXXVI, 1039). For example, it has been found that the particles in crude potashes that show a red fluorescence consist of potassium sulphide, while the blue fluorescent particles are mainly composed of compounds of organic and mineral matter.

Again, this instrument shows that the orange fluorescence of mercuric chloride is caused by the presence of particles of mercurous chloride, the fluorescence of which disappears on heating. If mercuric chloride is chemically pure it does not fluoresce, but traces of calomel may be detected by the luminescence test in many of the preparations on the market, although they would escape detection by chemical tests. When pure mercuric chloride is re-sublimed in a tube, the orange fluorescence will appear, showing that traces of calomel are produced in the process.

In like manner, pure anthracene shows a blue fluorescence, but when impure fluoresces green, owing to the presence of a substance showing a yellow fluorescence.

FORMATION OF PETROLEUM PRODUCTS.—It is highly probable that a process of filtration through porous media has played a part in the natural fractionation of petroleum, and this separation was attributed by Day to the differences in the speed of the diffusion of the different constituents through the capillary passages between the granules of porous earths. From the recent experiments of Gurwitsch, however, (*Petroleum*, 1912, VIII, 65) it appears more likely that the separation is due to the attraction or absorption of the petroleum compounds by the particles of the porous earth. Thus, when the same oil was filtered through different porous media, the fractionation followed a very different course; while, on the other hand, filtration of a benzine solution of a petroleum product through a siliceous earth termed floridin gave exactly the same result as when the solution was shaken with the earth, 9·9 per cent. of the constituents being retained in each case.

The results of treating a white vaseline for four hours at a high temperature with forty per cent. of floridin were very interesting. The original vaseline contained 9·35 per cent. of paraffin wax, and had a viscosity of 6·7 degrees in Engler's apparatus, but after the treatment the paraffin wax had fallen to 6·80 per cent. while the viscosity had risen to 12·6 degrees. It thus appears that, contrary to the generally-accepted view, treatment of petroleum products with adsorbent agents may cause an increase in their viscosity.

POISONOUS GASES FROM OIL FIELDS.—Mr. H. S. Shrewsbury records a case of a man being killed by breathing the gas at the bottom of a pit beneath a derrick at an oil well near Pitch Lake, Trinidad (*Analyst*, 1912 XXXVII, 486). A sample of the gas issuing from the top of the well was found to have the following composition:— Sulphuretted hydrogen, 0·2; carbon monoxide, 1·9; unsaturated hydrocarbons, 4·4; saturated hydrocarbons, 7·8; carbon dioxide, 20·9; hydrogen, 31·4; and nitrogen 33·4 per cent.

Since 0·1 to 0·15 per cent. of sulphuretted hydrogen is fatal to human life, while 0·15 per cent. of carbon monoxide is dangerous, and 0·4 per cent. of that gas will destroy life in a short time, it will be seen that the gas issuing from the oil well was extremely poisonous, and that even when mixed with about forty-three per cent. of air, as it was at the bottom of the pit, it would kill in a short time. The gas issuing in bubbles from the small channels and pools of water on the Pitch Lake, and that given off by the pitch itself, had the same tarry and sulphuretted odour as the poisonous gas from the oil fields. It is remarkable, however, that small fishes live in the pools, through which this poisonous gas is constantly bubbling.

It is suggested that this emission of poisonous gas from oil fields is probably not an uncommon occurrence, and that now that attention has been called to the danger, suitable precautions may be taken to prevent accidents.

REDUCTION OF METALLIC CHLORIDES BY SODIUM.—A communication by Mr. M. A. Hunter to the Eighth International Congress of Applied Chemistry (1912, *Orig. Communications*, II, 125) gives an account of the results obtained by reducing certain chlorides with metallic sodium in a steel bomb. The chlorides of titanium and beryllium were rapidly reduced to the metallic form, and beads of the metals were deposited on the walls of the bomb. In the case of titanium, in particular, the metal was pure and could easily be separated. Neodymium chloride also yielded the metal, but in a condition in which it could not readily be separated from the other substances.

Silicon chloride was also reduced with difficulty to silicon, while compounds of carbon, such as carbon tetrachloride and sulphide, yielded elementary carbon mainly in the amorphous state, though also containing a little graphite and a microscopic amount of colourless crystals agreeing in properties with crystalline carbon. Among the by-products of the reaction were sodium carbide and carbon hexachloride.

USE OF COPPER SULPHATE FOR PURIFYING WATER.—Several years ago an account was given in these columns of the good results obtained by using copper sulphate to remove vegetable growths from large reservoirs in the United States. Since then the process has been adopted in many other places, and in the *Journal for Gas Lighting*, 1912, CXIX, 507, Mr. G. Embrey describes the results of his experience with this method of purification at the Gloucester reservoirs, the water of which had become coloured and had acquired a fishy odour owing to the growth of *Chara vulgaris*. Experiments showed that as much as one part of copper sulphate per million could be used without rendering the water poisonous to fish or to human beings, but in practice a third of that quantity proved sufficient to destroy *Chara* and similar low forms of plant life.

This proportion of the salt was sprinkled over the surface of the water in the form of a fine powder, which sank to the bottom before dissolving. By this means the maximum action of the copper sulphate was brought to bear at the place where it was most needed. The water, after standing for a period of three to seven days, had lost its colour and unpleasant odour, and showed no copper remaining in solution. By treating the reservoirs in February, when only the diatoms were present, the subsequent development of *Chara* and confervoid growths was prevented. The trout in the water were not affected by the treatment, but the destruction of the vegetable matter caused starvation of the roach. The copper added to the water was partially deposited in the form of red cuprous oxide on the stones, and was converted into black cupric oxide by exposure to the air.

Higher forms of vegetation are not injured by such proportions of copper; for it was found that algae could be destroyed in watercress beds without injury to the plants.

THE MANUFACTURE OF CARBON BLACK.—In the United States a sharp distinction is made between "lamp black," the soot deposited when an oil or resin is burned in a limited supply of air, and "carbon black," which is obtained by applying a cooling surface to a burning flame. A description of the process used in a factory producing about ten thousand pounds of carbon black a day is given by Mr. G. L. Cabot in a paper read at the Eighth International Congress of Applied Chemistry (*Original Communications*, 1912, XII, 13).

The bulk of the carbon black in the American trade is derived from natural gas, which is ignited as it issues from the ground, and consumed in rotating burners which pass beneath fixed cooling plates, upon which the soot is deposited. Most of the attempts to produce the black from petroleum oil are stated to have been commercially unsuccessful.

Carbon black as scraped from the plates has a specific gravity of about 1·7 after removal of the "air" with which it is impregnated. It is much superior in tone to ordinary lampblack, since it possesses a rich "bloom," which makes it a highly-prized pigment for the preparation of the best kinds of printing ink and stove polishes. Lampblack, on the other hand, is mainly used for colouring leather, unvulcanised rubber and oil cloth, and in the manufacture of paints. Its chief source is tar oil, which when burned in furnaces of special construction provided with cooling chambers, yields from fifteen to thirty-five per cent. of its weight of lampblack.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

GEOLOGY OF DARTMOOR.—An interesting Memoir with this title has been issued by the Geological Survey, and describes an area of two hundred and sixteen square miles in Devonshire, including the greater part of Dartmoor. The geology is, of course, mainly that of the great granite mass forming Dartmoor, which is intrusive in rocks up to Carboniferous in age. It probably forms a gigantic laccolite whose upper surface slopes gently under the adjacent sediments. Patches of contact-altered Carboniferous rocks have been found a mile within the granite boundary, and these afford data from which the general dip of the granite below the sediments can be estimated. Near Petertavy and Marytavy the angle is from twenty-three degrees to thirty-two degrees, and its smallness accounts for the great width of the metamorphic aureole in that district.

The Dartmoor granite is a coarsely porphyritic rock with large phenocrysts of white felspar which are arranged in fluxion-streams near the boundary with the sediments. Tourmaline is present in most parts. Topaz and cordierite also occur, but much less frequently. The Dartmoor granite is of a more normal type than the other western granites. It is less acid and has suffered less from pneumatolysis. It may be described as a biotite granite, or granitite with accessory tourmaline, whereas the other granites from the West of England usually contain abundant muscovite in addition. Its felspars are of more basic composition, and oligoclase is frequently present.

The great mass of the Dartmoor granite and its slow cooling has led to extensive contact-metamorphism in the adjacent sediments. The average width of the contact-aureole is one mile, and as a large variety of sediments of Carboniferous and Devonian age are involved, a correspondingly large variety of types of hornfels, spotted slates, and tourmalinized rocks occur, and shew many different stages of recrystallization. On the south and south-east the argillaceous sediments have been converted to fine cordierite-hornfelses. Andalusite slates and chiastolite slates also occur. A special belt of dark shales is always the parent rock of the latter. The impure calcareous sediments which are found within the aureole are especially susceptible to contact-alteration, and give rise to a variable series of calc-silicate hornfels, of which the most interesting are the scapolite-bearing types.

The spilite lavas and intrusive greenstones which occur in the Devonian and Carboniferous rocks are intensely contact-altered where they appear within the limits of the aureole. The spilite-hornfels are fine-grained banded schists containing abundant hornblende, with biotite, felspar, quartz, and occasionally much epidote. In both the spilite and greenstone-hornfels occur certain minerals, notably tourmaline and axinite, which must be ascribed to pneumatolytic origin.

IRON-ORES AND BAUXITES OF NORTH-EAST IRELAND.—The iron-ores and bauxites, which form a prominent stratified zone in the midst of the Tertiary basaltic series of north-east Ireland have been described by Professor Cole and his coadjutors on the Geological Survey of Ireland in a recently issued Memoir. These rocks are coloured bright red, and are conspicuous at the Giant's Causeway, where they separate an upper series of massive columnar lavas from a lower series of thinner flows. They were formed by the weathering of the lavas during a quiescent period of the Antrim volcanoes. The materials of the interbasaltic zone are pisolitic iron-ores, laterites, and bauxite clays. The typical downward succession in Antrim is (3) pisolitic iron-ore; (2) "pavement," a material with a false stratification due to coloured streaks of basaltic decomposition, and varying from a siliceous iron-ore to a lithomarge; (1) lithomarge, a decomposed basalt still retaining the joint structures and showing the spheroidal weathering of the original rock. The pale bauxite clays in Antrim have been derived from rhyolites, although the formation of bauxite from basic igneous rocks has been proved in other localities. They overlie the pisolitic iron-ore when they occur. The whole of the deposits may be compared with the products of the process of laterization now going on in many tropical regions, and resulting in the very variable material known as laterite. The first chapter of the Memoir, by Professor Cole, is a valuable summary of views of laterite-formation. He comes to the conclusion that the laterites and lithomarges of north-east Ireland must be regarded as examples of soils and subsoils formed under more or less tropical conditions in a region of seasonal rains.

MICROSCOPY.

By F.R.M.S.

A RARE (?) ALGA.—Many species of the Oscillatorias are among the most common examples of low plant life. Some of them may be found in nearly every pond and pool of water, on heaths and open spaces, while on wet muddy paths, at the base of walls, and round trees they frequently show as a dark

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bluish-green stain. In these cases they appear under the microscope as fine threads of some shade of green, indistinctly divided into numerous short cells, and when sufficiently free exhibit the gliding and *oscillating* movements which have given rise to their name. But the family contains also some more specialized members which are less often met with. In October last, I came across a solitary example of one of these, clinging to a piece of *Myriophyllum* in a pond on Hampstead Heath. In it a number of separate threads (trichomes) are enclosed in a sheath-like case of gelatinous matter; they are somewhat twisted and form a rope-like object. Individually, they do not differ in any respect from many species of

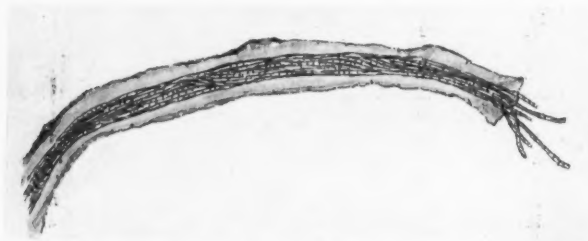

FIGURE 94.
Microcoleus subtorulosus Bréb.

oscillatoria, but movement must be very restricted from their close apposition and confinement within the investment. It evidently belongs to the genus *Microcoleus* Des., 1823 (*Cthonoblastus*, Kützing 1843). West says of *Microcoleus* —"The filaments are simple, terrestrial or aquatic in habit, and are furnished with a conspicuous hyaline sheath. This sheath is more or less cylindrical, not in any way lamellose, and its apex is generally diffluent. The trichomes are numerous, closely aggregated within the central part of the sheath, and often spirally interwoven." My specimen agrees very well with his *M. subtorulosus* Bréb, the thickness of the trichomes being, as he states, about 5μ, the breadth of the entire organism, including sheath, from 75 to 80μ. He says "Plants of this genus are very rare in Britain." Dr. Cooke, "British Freshwater Algae," and "Introduction to Freshwater Algae," gives three species not corresponding very satisfactorily with West's; this specimen seems to resemble his *M. terrestris* most nearly. The chief difference in the descriptions is that he appears to imply that *Microcoleus* is frequent instead of rare; he says of its habitat, "on moist naked ground" and "on the naked ground by roadsides," and so on. I have only met with the plant once before, and on neither occasion in any quantity, but it may occur more often in other parts of the country than near London. If any of the readers of "KNOWLEDGE" have been fortunate in coming across it in greater abundance, a note with some details would be welcome to me, and the Editor would, no doubt, be good enough to insert it in "Microscopy." Figure 94 represents almost the whole of the specimen referred to, the remainder being somewhat broken and disorganised.

JAMES BURTON.

QUEKETT MICROSCOPICAL CLUB, January 28th.—A. A. C. Eliot Merlin, F.R.M.S., sent for exhibition a photomicrograph at ×320 of *Coscinodiscus heliozoides* showing "pseudopodia," from a preparation by J. D. Siddall.

"Some notes on the Discoid Diatoms" were contributed by W. M. Bale, F.R.M.S., of Victoria, Australia. The paper is a survey and criticism of the principal characters which have been utilised in the discrimination of species in some of the best known genera of the discoid diatoms. *Coscinodiscus*, *Actinocyclus*, *Asteromphalus*, and *Actinoptychus* are dealt with.

A paper on "British Freshwater Planarians (Rhabdocoelida)" by H. Whitehead, B.Sc., was read. While the British *marine* Turbellaria have been monographed by Professor Gamble, the *freshwater* forms of this country have received but little attention. The classic monograph on the group Rhabdocoelida is by von Graff. These organisms vary in length from about one to twelve millimetres. They are generally found in ponds, lakes and ditches. The body is more or less transparent, is slightly flattened and provided with cilia. There is a mouth, a pharynx, and a sac-like gut. The position of the mouth varies and affords a valuable generic character. The excretory system consists of renal organs which in some cases are somewhat complicated in character. The nervous system is simple and comprises a two-lobed brain and a pair of nerves running along the body close to the ventral surface. Pigmented eyes are sometimes present, and a statocyst (organ of equilibration) is occasionally found. Reproduction is usually sexual. The animals are hermaphrodite, but the male organs ripen first. Freshwater Turbellaria undergo no metamorphosis. Reference was made to the green chlorophyll-containing cells found in some species. Professor Keeble has proved that in an allied marine form, *Convoluta*, there is mutual benefit from the association of these green cells (zoöchlorellae) with the animal. The Rhabdocoels are very difficult to prepare in a satisfactory manner as permanent objects. The most successful method is as follows:—The specimen is placed in a watchglass with a little water, the bulk of which is withdrawn by a pipette. A drop of Lang's fluid is then delivered from a pipette on the side of the watchglass and allowed to run over the animal. After remaining in the fluid for ten to fifteen minutes, the specimens are removed to forty-five per cent. spirit, and are afterwards passed through alcohol of increasing strengths, stained with borax-carmine, and mounted in Canada balsam in the usual way.

In a note on *Pleurosigma angulatum*, E. M. Nelson, F.R.M.S., stated that in spite of previously expressed opinions, the apertures in the lower membrane of this and allied forms can be unmistakeably seen below the intercostals of the upper. Objective used was a Leitz one-twelfth apo. of 1·4 N.A.

C. F. Rousselet, F.R.M.S., read a note on "Some Rotifers from Devil's Lake, North Dakota, U.S.A."

A DARK GROUND ILLUMINATOR.—Mr. E. M. Nelson, F.R.M.S., has recomputed a dark ground illuminator (see Figure 95) which is particularly useful for the examination of living bacteria. It is claimed that it produces a brilliantly illuminated object on a velvet black background. It can be used with both dry and immersion objectives, but the numerical aperture of the latter has to be reduced by a small stop placed just above the back lens. A funnel stop is recommended, which can be fitted to any immersion objective at a trifling cost, and can be taken out quite easily when not required. The great point of the illuminator is that whereas those at present in use require a powerful arc-lamp, Mr. Nelson's can be used with an ordinary oil lamp and a bull's eye condenser, provided that the work is done in a darkened room. Mr. C. Baker, who is producing the illuminator, recommends a Nernst lamp with a Nelson Aplanatic bull's eye condenser attached, but incandescent and petrol gas lamps can also be used.

FIGURE 95.

ON THE RELATION OF APERTURE TO POWER.—A theory founded upon mathematical fact there is no gainsaying, yet, while admitting the theory, one need not always accept the proposed application of the principle. All praise is due to Mr. E. Ardron Hutton for the care with which he has prepared his article, under the above title; for his clearness in marshalling his figures, yet when it comes to marching under his banner I find his colours are not mine.

With his strictures upon opticians, each, according to him, striving, in large apertures of the micro-objective, to offer better bargains than his fellows, I am not concerned. True, my own reading of their catalogues does not confirm these, but the makers are quite capable of defending themselves, and need no help from my pen. Then, however, he goes on to say: "In the above case A (from offering the largest

aperture) would often get the order, the tyro arguing that increased N.A. meant more resolution and, therefore, better results. It is altogether forgotten that behind everything is the human eye, and that this admits of improvement within but narrow limits."

With the inference he draws from this I am entirely at issue. The tyro does get more resolution and better results out of the larger aperture, within, of course, certain well-defined limits, though I doubt whether A is foolish enough to give it for nothing. I confess, indeed, to finding it a little difficult to follow Mr. Hutton in his arguments to prove the contrary. Certainly there are limits to the ability of the eye to separate lines beyond a certain fineness apart. I cannot, however, see the connection of this with the microscope, when the very object of the instrument is to carry on definite vision still further and further than the unaided eye can command.

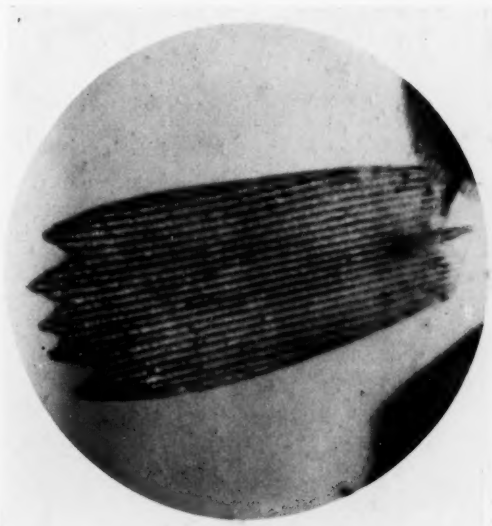

FIGURE 96. A scale of Butterfly, *Vanessa atalanta*, magnified four hundred and seventy diameters. Taken by an objective of 0·17 N.A.

Up to a certain point I agree. I admit, taking his words: "An objective of 0·13 N.A. will resolve twelve thousand five hundred lines to the inch. . . . To accomplish this the objective must have an initial power of ten, which, multiplied by ten (the power of the eyepiece), and then the one hundred and twenty-five (the limit of resolution of ordinary eyesight), gives us the twelve thousand five hundred." Granted, that if such an objective were constructed, which with the ten-power eyepiece would resolve just these number of lines, and no more, granted also the limit mentioned of the observer's vision, he would not be able to pick up details in the object of still more fineness. Even if the objective had double the N.A., could resolve, in fact, lines of double the fineness, and these in the object; with the ten-power eye-piece they would still remain invisible. In this last case, however, what is to prevent the tyro from clapping on a twenty-power eyepiece, when they would at once be seen? For myself, I can separate two hundred and fifty lines to the inch, yet it often occurs that details invisible under an eight-power eyepiece become clearly defined under an eighteen or even twenty-seven. But, then, I do not confine myself to objectives with narrow apertures. To construct, indeed, an objective with an N.A. so limited as to show things under a ten-power eyepiece only; then another of double the N.A. to be able to resolve structure of double the fineness, and no more, under the same conditions; would be, to my seeming, to emulate the man who cut two holes in the door for his cats to go through, the larger one for the mother cat, the smaller for her kitten, oblivious of the fact that the larger aperture would suffice for both. Here, as in other things the greater includes the less.

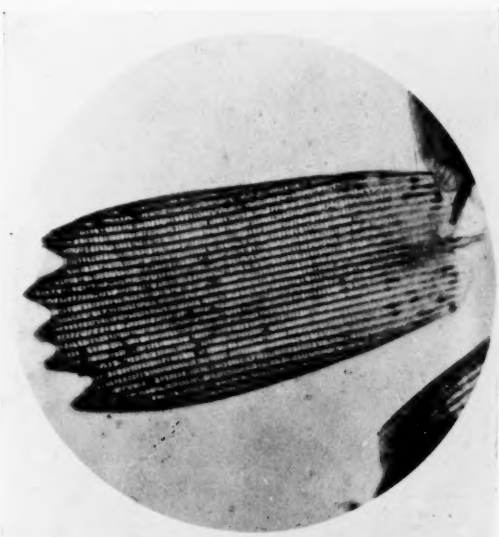

FIGURE 97. The same scale taken by Swift & Son's new two-thirds inch apochromatic objective of 0·30 N.A. Magnified four hundred and seventy diameters, as before.

A micro-objective with reserve of aperture is a whole battery of lenses in itself, the progress from lower to higher magnification being made by changing the eyepieces instead of the objectives. Five eyepieces ranging from four to twenty-seven powers will give, with a two-thirds inch objective, on a seven-inch tube, magnifications of from forty to two hundred and seventy diameters.

I am assuming, of course, that the lenses are good; also that deep eyepiecing refers mostly to the low and medium powers. With an oil immersion one-twelfth inch I have never been able to work with advantage with anything higher than a twelve-power eyepiece, calculated upon a ten-inch tube. Here, again, I find myself at issue with Mr. Hutton. He says, when speaking of medium-power lenses, ranging from the one-inch to the half-inch or four-tenths of an inch:—"These admit abundance of light, and often possess a working distance equal to three-quarters of their focal length. They can scarcely be said to be used for highly critical work, and will (not?—T. F. S.) bear an eyepiece magnification at any rate more than ten." Then:—"So that nowadays every objective of four-tenths of an inch or lower will bear an eyepiece magnifying ten on the one hundred and sixty millimetres tube. Even then we must be careful as to the illumination, or we shall only get a foggy glare."

To me this statement is truly astonishing, since, if there is one thing more than another which distinguishes these low and medium powers from the highest, it is their capacity to stand deep eyepiecing. Why, some of my lower powers only begin to do their work when under a twenty-seven eyepiece. This especially applies to a new two-thirds apochromat of Swift and Son, just acquired, of 0·30 N.A.; also to a half-inch of theirs of 0·50 N.A., and a B.B. of Zeiss of the same aperture, all in my possession. I only speak of my own glasses, but others, no doubt, of other makers, will do the same. Knowing what my own lenses will do under my own microscope, it would almost seem that Mr. Hutton's labours had ceased with compiling his figures, and that he had taken no further trouble to verify his conclusions. I should be sorry to misrepresent him, yet what is one to think when theory and fact are so far apart as here?

Happily, the micro-camera is ready to come to our aid to judge between us, and let the microscopical readers of "KNOWLEDGE" be the umpires. True, in theory, photography is supposed to confer extra resolving power upon the micro-objective, yet in practice I have never found it so. In this opinion also, I am confirmed by Mr. Andrew Pringle, whose authority on the subject is second to none. I remember many years ago attending a

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lecture on Photo-micrography given by him before the Photographic Society, now the Royal. After the lecture a gentleman asked a question as to the increased resolving power photography gave, instancing examples in the sister science, where more stars were seen upon the negative than in the telescope. A facetious gentleman among the audience called out: "That depends upon the plates," meaning, of course, the more holes in the plates the more stars. Mr. Pringle's sober answer was that although he had often seen details of structure upon the negative not noticed in the microscope, when he referred back to the microscope they were always there visually. If I may refer to a matter touching myself personally, I may say that though, according to the Psalmist past the age of man, my eyesight is as good as ever it was. What the plate can see, I can see in the microscope, and that is the way I test it.

The photo-micrographs here given, then, may be taken as true representatives of what was seen, and not seen, in the microscope. Figures 96 and 97 are from a butterfly's scale, Figure 96 being taken with a lens of 0·17 N.A., the outside limit Mr. Hutton will allow for a two-thirds inch. Figure 97 by my own two-thirds apochromat of Swift, N.A. 0·30, both magnified four hundred and seventy diameters, or forty-seven times the initial power of the objectives on a seven-inch tube. Now, can anyone hesitate for a moment in deciding which picture shows the most detail? Photographically, in the quality of the prints there is not so much difference. When we come to examine them, however, we find that while Figure 96 shows only the ribbing running from end to end of the scale, with just indications of the coarser cross ribbing at the tip; in Figure 97 the cross striations are crowded from end to end. Neither can it be said of the second that the magnification (equal to a forty-seven power eyepiece) is too much for clear definition in the print, nor again that the image has broken down, or is foggy. I would not for a moment, however, let it be thought that the objective, by which the first print was taken, is a bad one. Indeed, it is very good, but, of course, cannot show structure beyond the limits of its aperture. One might as well expect a pony to do the same work as a dray horse.

So much for the lower and medium powers. I now beg to deal with another statement concerning some of the higher, and am sorry to say that to deal will be also to disagree.

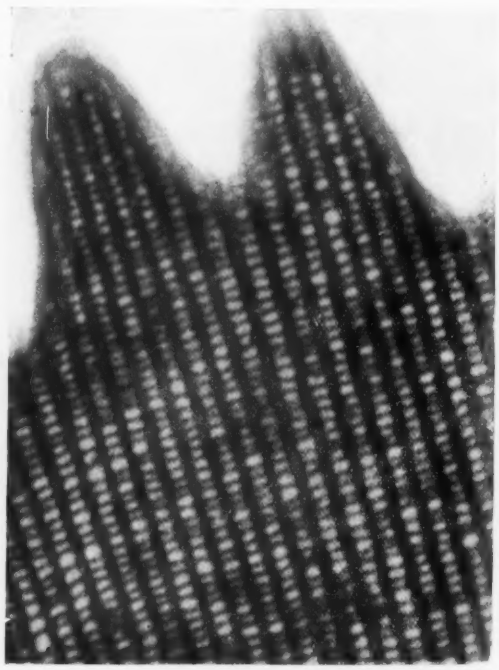


FIGURE 98. Part of a scale of the same Butterfly, magnified one thousand five hundred diameters. Taken by a half-inch of Swift & Son's, of 0·50 N.A., abnormally magnified to compare in size with Figure 99.

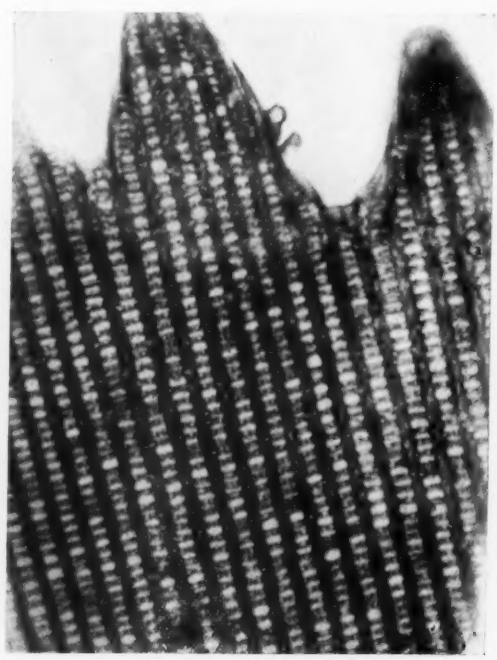


FIGURE 99. The same part of the same scale, magnified one thousand five hundred diameters to show bosses on the cross ribs. Taken by a one-sixth inch of Swift & Son's, of 0·85 N.A.

Mr. Hutton's ideal aperture for a four millimetre (one-sixth inch) is 0·52 N.A., and he says: "It is, however, useless to give us a four millimetre (one-sixth) objective of 0·88 N.A., as its aperture could not be fully utilised except by employing such high power eyepieces, or lengthening the tube, as would utterly break down the critical character of the image. Anything above 0·52 N.A. for such an objective is of little or no value, and if working distance is sacrificed to obtain a higher aperture it is worse than useless."

Here, again, we can bring photography in as an impartial, though striking, witness in the case. I am lucky also in being able to reproduce the image of the same object by the two apertures, or nearly so, he mentions. Figure 98 was taken by a half-inch of 0·50 N.A., and Figure 99 by a sixth-inch of 0·85 N.A., both of Swift. The first falls two points below Mr. Hutton's ideal, it is true, the other, three points below the one he reprobates, yet I doubt whether it will affect the definite picture in either case. Both are taken at twenty-five times the initial power of a one-sixth, being, so far as the half-inch is concerned, equal to the initial power of seventy-five times upon a ten-inch tube. My sole object in this last was that the two objects of the same size might be compared, fifteen hundred being far past the point, on this glass, of useful magnification.

Figure 98, however, teaches a useful lesson in another way. Practically, there is not much more seen of the structure than is shown in Figure 97, simply long girder ribs with short ones at right angles between. In Figure 99 one sees that the cross ones are beaded, pointing to further structure in the scale. This beaded appearance is due to little bosses, which, rising from the cross ribs, support a structureless membrane on the top. Now, the half-inch being of 0·50 N.A. gives a slight hint of this structure, though not enough to be of much service, as it appears under a low eyepiece. So far, however, from a deep eyepiece helping, it only obliterates entirely what was but slightly indicated before. The reason is not far to seek. Assuming that a twenty power eyepiece is substituted for the one of ten, each point of structure has only one quarter of the light. This being now insufficient

to stimulate the optic nerve, the picture is lost altogether.

The failure to define, however, by the glass of 0·50 N.A., which is so well shown by the N.A. of 0·85, is not all due to the want of resolving power in the former. Could the little bosses be isolated from the cross ribs they would be seen by the smaller N.A. readily enough. But here, with the larger aperture of the one-sixth inch comes in another valuable quality, seemingly not appreciated by Mr. Hutton. It does not consist of the depth of focus he speaks of. Rather this is its opposite, allowing two structures, one superimposed upon the other, and but a little apart, to be separated optically. In the words of Dr. Abbe, a wide aperture then becomes an optical microtome. In conclusion, I have not met all his points, but have already written enough, I think, to give a good opening for the discussion which I hope will follow.

T. F. SMITH.

THE ROYAL MICROSCOPICAL SOCIETY.—At the meeting held on February 19th, the new President, Professor Sims Woodhead, took the chair for the first time. Mr. E. J. Spitta gave a very interesting account of the lenses formerly belonging to Joseph Lister, which had been presented to the Society by the Executors of his son, the late Lord Lister. Many of the lenses were of great historical interest. Some of them had been made by Joseph Lister himself, others appeared to be the first examples produced by well-known makers. Among the manuscripts which accompanied the apparatus was a paper which, so far as Mr. Spitta had been able to determine, had never been published, in which Joseph Lister, had in a marvellous way anticipated the work of Abbe carried out forty or fifty years later. A remarkable feature of the lenses made by Lister himself was the high polish which had been given to them. This is more to be wondered at seeing the methods which had to be adopted.

FIGURE 100.

A New Nesting Box for Nature Study Observations.

Mr. C. Lees Curties exhibited, on behalf of Mr. H. Waddington, a striking series of slides illustrating the development of the Fairy Shrimp (*Chirocephalus diaphanus*). These included the egg and several examples of the nauplius in various stages, as well as the young shrimps and preparations illustrating parts of the full-grown animal. Dr. Shillington Scales read the notes which were sent with the slides, from which it appeared that the crustacean while of only occasional occurrence in England generally, was not uncommon in parts of Cornwall. To the list of localities mentioned, Mr. Wilfred Mark Webb added Eton, Mr. D. J. Scourfield one near Oxshott, while Mr. John Hopkinson mentioned a record for Hertfordshire.

Mr. D. J. Scourfield described the use of the centrifuge in pond-life work, pointing out that organisms could be obtained from water that was apparently free from them by the use of this apparatus. He said that in the past it had been taken up rather as a substitute for fine nets, but it should be looked upon as supplementing them.

Another feature which contributed towards making a most attractive meeting, was the exhibition of Desmids by members of the biological section of the Royal Microscopical Society.

TAKING CINEMATOGRAPH PICTURES WITH THE MICROSCOPE.—We have received a very useful booklet entitled "Guide to Photo-micrography." It is published by Mr. E. Leitz, and it was primarily prepared for users of apparatus supplied by him. In the first place we are told how to set this up, and to make photographs with the camera put vertically and horizontally. Special apparatus for photographing insects, large sections, and solid objects, is illustrated and described. The photographic side of the work is dealt with as is also the making of cinematograph pictures. Altogether the Guide is a very valuable help to those who wish to take up photo-micrography in connection with their work or as an attractive hobby.

ORNITHOLOGY.

By WILFRED MARK WEBB, F.L.S.

A SWALLOW RINGED IN STAFFORDSHIRE AND RECOVERED IN NATAL.—On May 6th, 8911, Mr. J. R. B. Masefield ringed two swallows (*Chelidon rustica*) which were nesting in the porch of his house, Rosehill, Cheadle, Staffordshire. In the summer of 1912 he again caught the swallows nesting in the porch but found that only one of them bore the ring which he had put on in the previous year. On December 23rd, 1912, a swallow was caught in a farmhouse eighteen miles from Utrecht in Natal, and this proved to be the bird which did not return to Cheadle in that year. Mr. Harry Witherby, who records the occurrence in *British Birds* for February, thinks it extraordinary that a swallow breeding in the far west of Europe should have reached the south-east of Africa. He finds it is quite impossible to theorise on a single recovery of this kind but tells us that we must be content at present with the bare fact, probably the most startling one that the ringing of birds has as yet produced.

NESTING BOX EXHIBITION.—A very successful exhibition of nesting boxes, held during the first fortnight of February in the offices of the Selborne Society, was organised by the Brent Valley Bird Sanctuary Committee. The nesting boxes which, when they were first designed, were described and illustrated in "KNOWLEDGE" (Volume XXXIV, page 99), have now reached a stage at which they are not capable of very much more improvement, for they have been modified in the light of experience and the less successful forms have been dropped. There was nothing, therefore, very novel to be seen, though one box was interesting. Instead of being made from a small log, it is cut from half a tree trunk (see Figure 100). This gives it a flat back, and it is very suitable for hanging on a wall, amongst ivy, for instance. The top lifts off for observational purposes, and instead of being fixed by nails driven through metal plates the box can be hung on a single hook. It is specially intended for nature study observations, and for use in school gardens and playgrounds, for it can be put up out of reach and taken down for examination by the teacher quite easily when required. As was seen at the Children's Welfare Exhibition, country children are able to make very excellent observations on birds which build in the open, and the use of nesting boxes gives them, as well as their town and suburban cousins, a chance of studying the nesting habits of those birds which customarily rear their young in holes. Another contrivance worthy of mention is an experimental box, made, with the idea of attracting tree-creepers, from a slice of a curved branch, the object being when it is attached to a tree to make it appear as if it were part of the actual trunk.

THE LATE STAY OF SWIFTS.—Mr. H. B. Booth, in *The Irish Naturalist* for February, criticises the expression used in previous notes on the Swift—"*despite* the coldness of August, and the summer, the Swifts did not depart." He says that the writers should have said *because* of the cold August and Summer, for his observations go to show that with the members of this species the date of their departure is fixed more by the forwardness of their young brood, and their ability to undertake the long journey, than by the state of the weather, or of their food supply at the time of leaving. As a matter of fact, in the finest summers and consequently when there is a large supply of winged insect food, the colony usually breaks up a day or two earlier than in colder and wetter seasons. It must be obvious that in the former case the young ones would be better fed, and come to maturity earlier.

XUM

PHOTOGRAPHY.

By EDGAR SENIOR.

REVERSED NEGATIVES.—For certain photographic processes, such as single transfer, carbon, and photo-mechanical printing, negatives are required in which the image is reversed as regards right and left, in order that the finished impression may appear in its correct aspect. The production of negatives of this nature may either be accomplished directly in the camera or indirectly by stripping the film from its glass support and turning it, or by reproduction from ordinary negatives. By the first method the reversal is generally obtained through the use of either a metallic mirror placed at an angle of forty-five degrees with respect to the axis of the lens, or by means of a right-angled prism, from either of which the image is obtained by reflection; in the latter, from the hypotenuse surface of the prism; and in the former, from the silvered surface of the mirror. As both of these pieces of apparatus are expensive, and, especially in the case of the mirror, easily damaged, a plan very frequently followed, and which, at the same time, is capable of giving good results, is to reverse the position of the sensitive plate in the dark slide. When working in this manner it is, of course, necessary to turn the focusing screen, for the purpose of making allowance for the difference in the image plane due to the thickness of the glass.

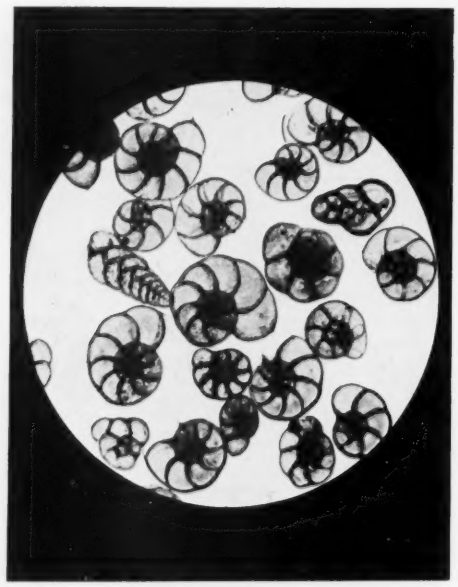


FIGURE 101.

Print from the original negative.

By the second method the film itself is stripped from its glass support. This may be accomplished in several ways. In the case of collodion negatives a coating of india-rubber dissolved in benzole is applied to the plate, and when this is dry (which only requires a few minutes) a film of stripping collodion is applied and allowed to become dry; the negative is then placed in a dish of water containing acetic acid, when, after several minutes immersion, the film begins to loosen from the glass, from which it finally floats free, and may be turned and floated on to another piece of glass which has received a coating of gelatine. We have also found the "Lotus stripping films" made by Messrs. Mawson & Swan very satisfactory, in which case the negative is permanently removed from the glass and used as a film. When gelatine is the medium in which the image is formed its removal from the glass plate is not so easily accomplished, apart from the expansion (which is often unequal) which the gelatine undergoes, and the consequent distortion of the image when transferred to another plate. A method was introduced years ago in which the gelatine plate was placed in a solution of fluoride of soda and citric acid, and although this method was found useful, the expansion was considerable and increased with the quantity of citric acid in the solution. To counteract this the application of a film of plain collodion was often resorted to. Owing to the evil results attending the operating with wet films, methods of stripping dry were introduced, the film being first thoroughly hardened by formalin in order to lessen its adhesion to the glass plate. For this purpose the following formulae due to E. Valenta may be employed:—

Formalin	...	150 minims.
Water	...	7 ounces.

The negative is allowed to soak in this solution for ten minutes, after which it is dried and coated with enamel collodion. The collodion film should be a thick one, and, when set, is well washed, and the negative cut through with a sharp knife about one-eighth of an inch from the edge of the plate all round. After drying the film with filter paper, the stripping is proceeded with, and, when accomplished, the negative is immersed in the following bath:—

Alcohol...	...	2 ounces.
Glycerine	...	2 ,,
Water ...	...	35 ,,

On removal from this solution the film is laid, collodion side down, upon a piece of glass which has been rubbed over with a little of the glycerine mixture, when a piece of filter paper is laid on and a roller squeegee gently applied, after which the plate is stood up and allowed to dry spontaneously. By the third method the reversed image is obtained by reproduction from an ordinary negative. This may be accomplished in several ways, one of which is to place a dry gelatine plate in contact with the negative in a printing frame, and expose to a strong source of light (sunlight) for a sufficient length of time to obtain a reversed action of light. A better plan, perhaps, is to employ the method adopted in the case of the example shown in Figure 101, which is due to Mr. Bolas:—A gelatine dry plate was soaked for three minutes in a four per cent. solution of potassium bichromate, after which it was rinsed for a few minutes in a bath consisting of equal volumes of alcohol and water. The superfluous liquid having been removed by means of filter paper, the plate was allowed to dry in the dark. When dry it was exposed under the negative from which the print in Figure 101 was made, for a time that would be required to obtain a carbon print from the same. After removal from the printing frame the plate was washed until free from the bichromate, and the image then developed by means of pyro and soda. After fixing and washing a negative in which the objects depicted were in the reverse aspect of the original negative resulted, and from which the print in Figure 102 was made. The

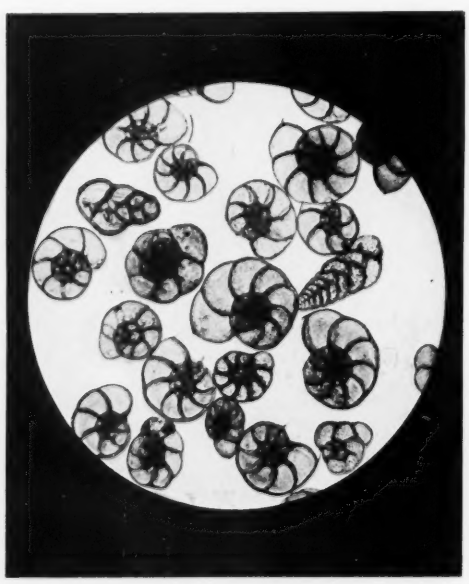


FIGURE 102.

Print from a reversed negative.

process itself is simple and with ordinary care is capable of giving good results, as is shown by the example.

ADON TELEPHOTO LENSES.—We have received from Messrs. J. H. Dallmeyer, Limited, a notice to the effect that the manufacture of the "Junior Adon" lens has been discontinued since February 1st, and that they will, therefore, be unable to execute any further orders for them. The manufacture of the well-known adjustable form of Adon telephoto lens, as well as the large Adons, working at F4·5, F6 and F10, for which the demand is very great, owing to the large scale of pictures and simplicity of manipulation, will be continued as before. The rapid fixed-focus Adons are meeting with great success, not only in their use on reflex and other hand-cameras, but as portrait lenses as well.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

FEEDING HABITS OF SERPENTS.—Raymond L. Ditmars, curator of reptiles in the New York Zoölogical Park, gives an interesting account of his observations on the feeding habits of snakes. They are exceedingly captious and sensitive. Changes of temperature and light, too much public inspection, the artificial environment, and so on, affect their nerves, and they go off their food on slight provocation. None are vegetarian; the majority like birds and mammals; a few are insectivorous; the sea-snakes confine themselves to fishes; some eat frogs, lizards and other snakes; some of the smaller forms condescend to earthworms. There are many specialisations in connection with feeding, one of the best known being that of the African egg-eating snake, *Dasypeltis scabra*, which swallows eggs three times the diameter of the thickest part of its body. The jaws are almost toothless, but a few posterior teeth enable them to grip the food. There is alternate gripping and engulfing, and the egg slips into the gullet. There it is cut by the knife-like points of the inferior processes of the vertebrae which project into the gullet. By this remarkable adaptation all wastage is avoided. The empty shell is afterwards passed out again—an absolutely unique habit. In other snakes that feed on eggs, the shells are broken by the snake forcing its throat against the ground. The fragments of the shell pass down to the stomach and are quite dissolved. In the Indian *Elachistodon westermanni* there is a structural adaptation similar to that of *Dasypeltis*, but there seems to be no certainty as to its use. Mr. Ditmars gives circumstantial details as to the diet of a large number of types, and leaves us with a vivid impression of the range of diversity in a single sub-class. What a contrast, for instance, between the diminutive worm-snake (*Glauconia*) of tropical South America, which lies unconcernedly inside the ant-hill devouring the larvae, and the huge Boa or the Anaconda, lurking in the jungle growth along the river banks on the watch for a passing peccary, capybara or agouti. An interesting general point is that with few exceptions there is an abrupt and entire cessation of feeding on the part of gravid females.

A MOTH'S LOVE SIGNAL.—Many experiments have been made to try to settle the much-discussed question whether insects hear or not, but they have not yielded satisfactory results, except in the way of showing that there are many sounds to which insects which are credited with the power of hearing pay no attention whatsoever. It is difficult, however, to believe that all the instrumental music of crickets, grasshoppers, cicadas, and the like falls on deaf ears; and Dr. Karl Peters suggests that the experiments that have yielded negative results have been too much restricted to sounds that have no biological significance to the creatures experimented with. He gives an instance, which he has carefully studied, which very strongly suggests that there may be hearing in the strict sense, and that the production of a sound may be utilised in love-making.

His observations relate to an Alpine moth (*Endrosa* or *Setina aurita* var. *ramosa*) which is abundant at Arolla, at a height of about two thousand five hundred metres. The males fly about actively; the females are sluggish and sit mostly on the tussocks of grass, where they are very inconspicuous. The males are able to produce a cracking noise, which is peculiar to them, and the females respond to this, even when they cannot see the males, by vibrating their body and wings. The reaction on the female's part begins when the male flies overhead or settles down close by; it stops when the sound stops. It seems difficult to avoid the conclusion that the female hears the male's love signal. It seems likely that sight plays a rôle on his part, and that the tremulous, vibrating movements of the female attract his attention.

RELATION OF HEART-WEIGHT TO MUSCULAR EFFORT.—A. Magnan finds that birds with relatively small wings and very numerous strokes per minute, have a relatively heavier heart than those with larger wings and more sailing power. Similarly, in Mammals, the proportion between weight of heart and muscular development is greater in Carnivores than in Herbivores. For while Herbivores can keep going a long time they have not usually that capacity for intense muscular effort which Carnivores show. It may be noted, however. that Magnan does not deal with horse or chamois or antelope, in which intense muscular effort is well known. It is interesting to notice that the proportion in the deer, the only large Herbivore measured, is more than double that of the rabbit. The highest proportion is found in bats which have such strongly developed pectoral muscles and "violent effort in their flight."

SLEEPING INSECTS.—Karl Fiebrig has made for many years a study of insects (in Paraguay), which exhibit definite sleep-attitudes, quite different from ordinary resting attitudes. The insects remain motionless and stiff, as if in a trance. Very characteristic is the clinching of the mandibles which close upon the supporting object. The whole weight of the body is often supported by the mandibles, no assistance being given by limbs or wings. In many cases of "sleep" the whole pose is unusual, being upside down or in some way reversed. The sleeping condition may be artificially induced by changes in the illumination. When "asleep" the insects are very callous as regards temperature, wind, touch and the like. The sleeping pose is often of protective value.

FIDDLER-CRABS.—A. S. Pearse has made an interesting study of the fiddler-crabs (five species of *Uca*), which swarm on the mud-flats at Manila. They live together in enormous colonies, but there is no social life in the true sense. In fact, they are extremely individualistic and pugnacious. "Each individual jealously guards the area about his own burrow, and immediately attacks any invader of this territory." The burrow is the centre of activities, and the association for the place where it is situated is very strong. The great chela of the male is used as a weapon in fighting, and Mr. Pearse cannot agree with Colonel Alcock that it is used as a signal to charm and allure the females. A very interesting description is given of the way in which the crabs carry mud away from the burrow and close the opening with a plug when they go into their retreat.

NEW RHIZOCEPHALAN.—Mr. F. A. Potts describes an extraordinary parasitic Crustacean, *Mycetomorpha vancouverensis* n.g. et sp., a new representative of the Rhizocephala. It occurs on the ventral surface of a shrimp, *Crangon communis*, and has a flat mushroom-like body of a pale yellow colour, with the borders fringed with numerous short lobes. Colourless, absorptive roots extend into the host below the nerve cord. The mantle cavity is full of *Cypris* larvae. No trace of a male organ or of larval males was to be seen, and it is suggested that the reproduction may be parthenogenetic. The same may be true of *Sylon* and *Sesarmoxenos*, two other strange Rhizocephala.

XUM

CORRESPONDENCE.

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—I am glad to take this opportunity of replying to Mr. F. W. Henkel's letter on the above, because he appears to have a definite argument to offer on the subject. This argument, if I mistake not, is that experience only gives us solid bodies, which we, somewhat arbitrarily, divide up into three dimensions, *i.e.*, that the concept of a three-dimensional body is not, as the term implies, a synthetic product, but is given immediately by experience; whilst the concept of a one-dimensional object (*i.e.*, a line) is not an element out of which the former concept is built, but is the product of analysis. Consequently, says Mr. Henkel, any argument based on the real existence of one-dimensional objects is fallacious, because such objects do not in fact, really exist. But . . . . in fact, I have a string of buts. First of all, I would ask Mr. Henkel what he understands by existence. What criterion of real existence can he offer which denies reality to that which exists in mind? But to leave aside the question of epistemological idealism, surely Mr. Henkel will not deny the existence of one- and two-dimensional objects as *aspects* of three-dimensional objects; and if this be so, there is nothing in his argument to prevent a belief that three-dimensional objects are merely aspects of four-dimensional objects, and so on *ad infinitum*. And that is exactly what I have suggested. Moreover, are all the objects of experience three-dimensional? I think not. Who has ever seen a three-dimensional body? I have not. What I only see, and what, I think, Mr. Henkel only sees, are flat, coloured surfaces (*i.e.*, two-dimensional). We simply infer them to be three-dimensional, because that is the idea we gain through our sensations of touch and motion. Indeed, by combining our sensations of touch and motion with our sense of duration, we may be said to experience four-dimensional objects—my experience, for example, tells me that the paper on which I write has length, breadth and thickness, and also duration in time. *i.e.*, it has *four* dimensions.

It is best, I think, to look at the subject from the point of view of motion. Experience tells me that I can move (to some extent at least) in an indefinite number of directions in space, but these may all be resolved into three (but not less) directions. The reality of the fourth dimension merely implies the possibility of movement in a new direction irresolvable into these three directions. As I have suggested above, time may be this direction: its apparent difference from the spatial directions being due to the fact that we are forced along time with no option of any other movement so long as that direction is concerned, and that we seem to have practically no power to see in the direction of time (unless, perhaps, memory is a sort of time-sight, and prevision be a fact).

THE POLYTECHNIC, REGENT STREET, LONDON, W. H. S. REDGROVE.

SOLAR DISTURBANCES DURING JANUARY, 1913.

BY FRANK C. DENNETT.

JANUARY was poorly favoured with suitable weather for the solar observer. Seven days (4, 10, 11, 19, 23, 29 and 30) were missed entirely. On eleven days (5, 6, 8, 9, 12, 13, 20, 21, 22, 24 and 28) the disc appeared free from disturbance, bright or dark. The longitude of the central meridian at noon, on January 1st, was 6° 12′.

No. 26.—A group belonging to December, which continued visible until January 3rd, and so appeared on the chart last month.

No. 1.—A group of two spotlets and two pores first seen on the 14th, in a faculic disturbance approaching the western limb. Next day only one pore was seen within a ring of faculae, very near the limb. The group appeared to be 50,000 miles in length.

No. 2.—On the 16th, an elongated faculic cloud well round the south-eastern limb was seen to contain a spotlet with a gray companion closely north of it, and a minute pore a little ahead. It remained visible as a hazy pore on the 17th.

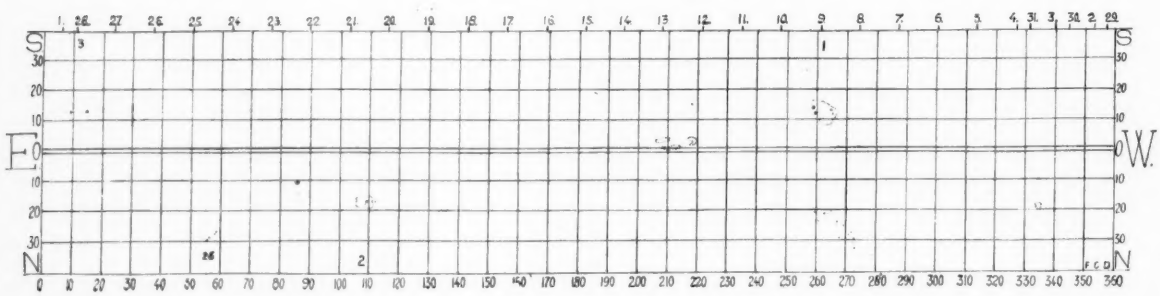
No. 3.—On the 25th, two spotlets were visible, and also on the 26th, but the distance between them had increased to 37,000 miles. On the 27th two pores were seen but not nearly so far apart, and there were traces of a minute point nearly in the place of the rear spotlet, but none were observed after.

The faculic display was also very little. On the 7th some was visible within the eastern limb, probably the remains of groups 24 and 24*a*, which is shown on the chart, longitude 206°–220°, as seen again on the 17th and 18th. On the later date less conspicuous faculae were recorded, but not measured, within the north-east and south-west limbs. On the 26th there was a bright knot at longitude 334°, 18° North latitude. On the 31st some faculic spots appeared in 30° North latitude between longitudes 41° and 51°, a little within the north-western limb, and doubtless were the remains of the disturbance which produced No. 26.

The helpers whose observations have contributed to the preparation of our chart are Messrs. J. McHarg, A. A. Buss, E. E. Peacock, W. H. Izzard, and the writer.

Erratum.—On p. 69, line 9 below the first chart, in the second column, for 228, read 288.

DAY OF JANUARY.



AUXETIC ACTION ON SPORES OF A NEW SPECIES OF *POLYTOMA*.

By AUBREY H. DREW.

Author of "The Life History of a New Monad."

Polytoma uvella was originally described by Ehrenberg, and subsequently studied by Dallinger and Drysdale. Saville Kent also did valuable work on this organism, and described a variety differing from the type by the possession of a red spot on the body, and consequently called *Polytoma ocella*. Dr. Dallinger referred to the organism as the Acorn Monad, and he and Drysdale were able to complete its life-cycle, while Saville Kent also added to our knowledge in this direction by showing that the knob-like appendages at the roots of the flagella, as described by Dallinger and Drysdale, were really in the nature of loops. Since the work of these observers little more has been done with regard to these organisms, nor has any new variety been described. In May, 1910, I had the good fortune to examine some Monads strongly resembling *Polytoma uvella*, and, indeed, at that time I classified them as such; but in February, 1911, I again came across the organism in a vegetable infusion, and noting after careful examination some peculiarities about it, I determined to study it further. I discovered with comparative ease that the organism was certainly a variety of *Polytoma*, as asexual reproduction was a division into four; and on carefully working out its life-cycle, I observed several very striking differences from *Polytoma uvella*, thus proving beyond a doubt that the organism was quite a new one. On account of its very striking granular appearance, I suggest that it should be named *Polytoma granulosa*. (See Figure 103.) This organism varies somewhat in size, but the average is between one fifteen-hundredth to one twelve-hundredth of an inch in length, the body is ovate, and is invested with a distinct cuticle, enclosing uniformly granular contents. A contractile vacuole is present, which is situated at the anterior end. The flagella are two in number, arising from the internal protoplasm, and piercing the envelope. They are equal in length, and exceed the body length of the monad. Occasionally they are crossed over each other, giving the roots a V-shaped aspect. Motion is rapid, but rather irregular, the flagella being used as the arms are in swimming, though the former are frequently not vibrated synchronously; hence irregularity in motion arises. The organism possesses a circular nucleus. This is situated about the centre of the body, but in ordinary individuals is invisible, owing to the granular contents. The nutrition is apparently mainly saprophytic, but is also holozoic at certain periods in the development of the organism. Reproduction is interesting, and takes place in the following manner. On studying a normal form it will be found in the course of time that a slight constriction is appearing in the granular sarcode, dividing the contents into two equal parts. This constriction deepens, and the contents retract somewhat at the equator of the organism. Soon two spherical masses of protoplasm are formed by this constriction. (See Figure 104.) During this process the monad is usually actively swimming, but now it generally comes to a standstill, and fixes itself anterior end downwards on the slide, and rapidly vibrates its flagella. Meanwhile each divided half undergoes a similar process of division, the fission this time being more or less transverse. Soon four granular masses are formed within the envelope, being arranged in a cruciform manner. Motion now usually ceases, the flagella being cast off, and the envelope with its contents alone remaining. A delicate membranous cuticle now forms around each of the products of fission, and minute flagella are developed, which commence to vibrate. Finally the separate organisms force their way out, leaving the envelope behind them, the entire process usually taking three or four hours. The method of anisogamic reproduction is far more difficult to ascertain, and requires careful and continuous observation over a length of time. If this condition is complied with, it will be seen that sooner or later a somewhat larger form in which the granular contents have retracted from the posterior end, and with the nucleus strongly developed, comes into contact with a normal form. The two adhere by the posterior ends, swimming being continued. (See Figure 106.) In the course of an hour or two motion usually ceases, both organisms adhering to the slide while the flagella continue in vibration. In about ten hours the two organisms gradually melt together, forming an oval sac which slowly becomes spherical. The sac is very granular and shows the two vestiges of the envelopes, which do not participate in the fusion. These vestiges are as a rule washed away from the sac by currents in the water, but occasionally persist adhering to it. The sac remains in this condition for many days, but it will be found that the contents are gradually merging into one another, forming an irregular mass of sarcode within. A constriction now appears in this sarcode, and division slowly takes place, two equal and slightly granular bodies of an oval shape being formed. An envelope appears around these organisms, and finally they acquire flagella, and, after a varying period, they escape, leaving the remnants of the sac. The completion of this process takes from five to eight days.

XUM

When I had worked out the life-history of the organism thus far, I naturally imagined that I had settled the whole life-cycle, and it was only by chance that I found that there was more to learn. These researches had been carried to this point in the summer of 1911, but being desirous of ascertaining conclusively whether the products of conjugation were ever more than two, I again made a series of observations in October, 1911. I then was fortunate enough to discover that there was a third method by which a winter resting spore was formed. Two organisms, both having their posterior ends comparatively free from granules, come into contact, and immediately adhere, the contents coalescing very rapidly, and give rise to a swelling between the remains of the two envelopes. Finally, a round sac is formed, with rather thick walls, and finely granular contents, with what is apparently a small bubble in the centre (see Figures 111 and 113). Practically every monad in the late autumn forms these sacs, reproduction by fission not taking place. In the course of some weeks the bubble-like body is absorbed, leaving the finely granular contents surrounded by the thick-walled sac. To study these spores further, they must be kept continually moist on a live slide of some sort through the winter, when it

FIGURE 103.
Polytoma granulosa sp. nov.
Normal free swimming form.

FIGURE 104.
Stages in division.

FIGURE 105.
Last stage in division and form prior to conjugation.

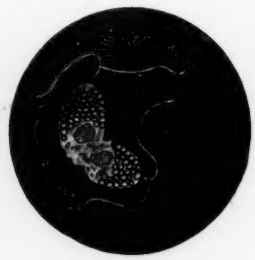


FIGURE 106.
Conjugation.

FIGURE 107.

FIGURE 108.
Stages in formation of winter resting spores.

FIGURE 109.
Sac formed from conjugation.

FIGURE 110.
Natural division in winter spore.

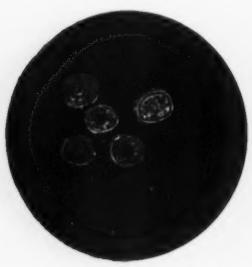


FIGURE 111.
Winter resting spores.

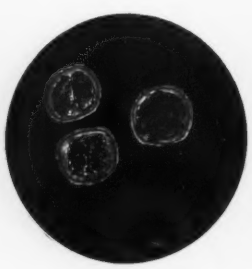


FIGURE 112.
Induced division in spores by Suprarenal Extract and Atropine.

FIGURE 113.
Controls and spores showing division. (Suprarenal gland and Cadaverine).

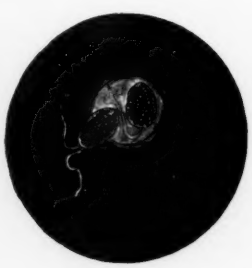


FIGURE 114.
Free forms from induced divisions.

All the figures are magnified 1000 diameters, except 111 which is enlarged 500 diameters.

will be found that towards spring the contents are gradually retracting from the sac wall, and, if at this stage the organism is very carefully watched day by day, it will be found that a division of the sarcode is taking place, in similar fashion to the ordinary one already described. Soon, the two organisms separate, acquire envelopes and flagella, and then the sac wall appears to give way, and finally they are liberated. If one of the free organisms is followed, it will be found to gradually increase in size till reproduction by fission takes place. The discovery of these winter resting-spores is important, as it explains how these organisms can survive the winter. I had previously noticed that normal forms were never to be observed during the winter months, and was now possessed of the explanation. During the autumn of the present year I was engaged in the further study of these spores, when it occurred to me that they formed a very suitable subject for testing the supposed action of Auxetics. Auxetics are substances discovered by Dr. H. C. Ross in 1909, while engaged in cancer research. Dr. Ross, and his colleagues at the Lister Institute, have shown that certain chemical bodies are developed during cell-death, and that these bodies act as excitors of cell-reproduction. Dr. Ross was further able to observe for the first time the division of human leucocytes by the action of these substances. Auxetics can be divided into two classes, natural and artificial. The natural auxetics are obtained from dead animal matter, especially material rich in lymphocytes. The artificial auxetics are bodies which contain the Amidine group, such as Theobromine, Caffeine and Acetamidine. Dr. Ross showed in addition that alkaloids were excitors of amoeboid action in leucocytes, and also that they acted as augmentors of auxetics. It had been suggested by critics that the mitotic figures obtained by Ross and his colleagues were artefacts, and I determined to experiment on the resting spores already described. Using a live slide containing spores through which a slow current of water could be passed. I accordingly prepared a solution containing four cubic centimetres of a concentrated extract of suprarenal gland, ·2 cubic centimetres of a one per cent. solution of atropine sulphate and ·5 cubic centimetres of a five per cent. solution of sodium bicarbonate. This was made up to ten cubic centimetres with distilled water, and the spores were kept continuously moist with this solution. In the course of forty-eight hours a slight constriction appeared in the sarcode which gradually deepened, and finally actually division took place, the products separating. (See Figure 112.) Controls containing no auxetics gave negative results. Working again with a very concentrated suprarenal extract augmented by the action of a one per cent. solution of Cadaverine I found that out of a total of forty-three spores in one field thirty-seven had undergone division within forty-eight hours. I was not, however, satisfied with this, as I was anxious to see whether the fully-developed organism could not be obtained from the spore. I accordingly worked with the solution just described, but kept the slide in the incubator at 25°C., examining the same at intervals of two hours. Division had commenced in forty-eight hours, in eighteen out of twenty-five in one field and the fully-developed organisms were formed after another thirty-six hours in seven of these eighteen; three spores actually discharged their contents, which swam away apparently normal in all respects. (See Figure 114.) I have also been able to obtain evidence of division upon auxetic jelly, containing stain, the full description of which is contained in "Induced Cell Reproduction and Cancer," by H. C. Ross (London: John Murray). This action of auxetics on these spores is extremely interesting, as it raises the point whether the former may not be necessary to cause the latter to develop in the spring. Pond water usually contains decaying vegetable and animal matter, and hence auxetics are probably present in solution. Whether it also contains augmentors one cannot yet say, though I am making experiments in this direction. From my own observations on these spores I am convinced that mere change in temperature will not explain the development in the spring, for spores may be incubated at summer temperature and still refuse to develop. Whether, with the advent of spring, auxetics and augmentors are formed in pond water in large quantities, and thus cause the dormant life to awake, is a point still to be settled, but in the light of present knowledge it appears extremely probable that the answer is in the affirmative.

I was afterwards able to improve the technique, and found that divisions could be more certainly induced if the water containing the spores was placed in small glass tubes, and the solution containing the auxetics then added. These tubes are then corked and placed in the incubator, and kept at 25°C for forty-eight hours, when portions of the contents may be examined from time to time. The possible production of auxetics in stagnant water is interesting, as cancer is often stated to be more prevalent in districts where stagnant water and decaying vegetation are present.

In conclusion, I have to express my indebtedness to Messrs. Watson & Sons, who kindly placed two of their new holoscopic objectives at my disposal, viz., a two millimetre immersion and a four millimetre dry, with the help of which several of the illustrations were made.

XUM

THE FACE OF THE SKY FOR APRIL.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 18.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Apr. 1	0 41·0	N. 4·4	21 10·6	S. 20·5	0 8·8	N 3·3	2 31·0	N. 21·9	19 9·6	S. 22·4	3 55·2	N. 18·6	7 39·9	N. 21·0
,, 6	0 59·2	6·3	0 47·8	N. 6·1	0 0·1	N. 0·9	2 30·5	22·2	19 11·6	22·3	3 57·3	18·7	7 39·9	21·0
,, 11	1 17·6	8·2	4 59·4	N. 27·8	23 59·1	S. 0·6	2 26·1	21·9	19 13·4	22·3	3 59·5	18·8	7 39·9	21·0
,, 16	1 36·0	10·0	9 56·9	N. 15·9	0 5·7	S. 1·0	2 18·2	21·0	19 14·8	22·3	4 1·7	19·0	7 40·1	21·0
,, 21	1 54·6	11·7	14 21·8	S. 17·4	0 18·4	S. 0·5	2 7·8	19·5	19 15·9	22·2	4 4·1	19·1	7 40·2	21·0
,, 26	2 13·3	N. 13·4	19 11·6	S. 27·5	0 36·0	N. 0·9	1 55·7	N. 17·8	19 16·7	S. 22·2	4 6·6	N. 19·2	7 40·5	N. 21·0

TABLE 19.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2	Saturn. P	Saturn. B
Greenwich Noon.	°	°	°	°	°	°	°	°	h. m.	h. m.	°	°
Apr. 1	−26·3	−6·5	260·6	−16·1	−8·2	−1·8	352·2	172·8	10 2 *e*	7 13 *m*	−2·8	−25·0
,, 6	26·4	6·2	194·6	−21·4	8·4	1·7	61·7	204·1	10 18 *m*	4 17 *e*		
,, 11	26·4	5·8	128·6	−5·6	8·6	1·7	131·3	235·4	8 24 *m*	5 29 *m*	2·9	25·2
,, 16	26·1	5·4	62·6	+18·7	8·7	1·7	200·9	266·8	4 20 *e*	2 33 *e*		
,, 21	25·7	5·0	356·6	+17·7	8·8	1·7	270·6	298·3	4 36 *m*	1 41 *e*	−3·0	−25·4
,, 26	−25·1	−4·6	290·5	−6·7	−8·9	−1·7	340·2	329·8	10 22 *e*	2 53 *m*		

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Jupiter L_1 refers to the equatorial zone, L_2 to the temperate zone, T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

THE SUN continues his Northward march. Sunrise during April changes from 5–38 to 4–37; sunset from 6–31 to 7–19. Its semi-diameter diminishes from 16′ 2″ to 15′ 54″. A small partial eclipse of the Sun on the 6th, is visible in Alaska and surrounding regions.

MERCURY is a morning star, well-placed for Southern observers. Illumination one-thirtieth on 1st, one-half on 30th. Semi-diameter diminishes from $5\frac{1}{2}''$ to $3\frac{1}{2}''$. Greatest Elongation, 27° West on 25th.

VENUS is an evening Star, till the 24th, when it is in inferior conjunction with the Sun, 6° North of it. Its semi-diameter is then $29\frac{1}{2}''$. It is of interest to see how near conjunction it can be followed. Sometimes the unillumined disc appears darker than the surrounding sky. Venus is 4° N. of Moon on evening of 8th.

THE MOON.—New $6^d\ 5^h\ 48^m\ e$; First Quarter $14^d\ 5^h\ 39^m\ m$; Full $20^d\ 9^h\ 33^m\ e$; Last Quarter $28^d\ 6^h\ 9^m\ m$. Apogee $2^d\ 8^h\ e$, semi-diameter 14′ 45″; Perigee $18^d\ 5^h\ e$, semi-diameter 16′ 29″. Apogee $30^d\ 1^h\ e$, semi-diameter 14′ 47″. Maximum Librations, 11^d 6° E, 12^d 7° S., 24^d 6° W., 25^d 7° N. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

TABLE 20. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.		h. m.	
Apr. 9 ...	66 Arietis	6·1	7 40 *e*	45°	8 29 *e*	293°
,, 11 ...	BAC 1648	6·4	6 51 *e*	66	7 53 *e*	296
,, 12 ...	BAC 1746	6·5	0 52 *m*	98	—	—
,, 17 ...	BD+12°2211	6·6	0 23 *m*	189	—	—
,, 18 ...	80 Leonis	6·4	2 50 *m*	139	3 40 *m*	280
,, 21 ...	BAC 4682	6·5	3 7 *m*	57	3 41 *m*	353
,, 22 ...	BAC 4923	5·7	0 39 *m*	69	1 28 *m*	345
,, 23 ...	π Scorpii	3·1	2 26 *m*	116	3 41 *m*	277
,, 27 ...	Lacaille 8248	7·0	—	—	2 32 *m*	180

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

MARS is a morning Star, but practically invisible.

JUPITER is still badly placed, having been in conjunction with the Sun on December 18th. It is a morning star. Polar semi-diameter, $18\frac{1}{3}''$.

TABLE 21.

Day.	West.	East.	Day.	West.	East.
Apr. 1	41 ○	2●3●	Apr.16	4 ○	132
,, 2	4 ○	123	,, 17	41 ⊙	3
,, 3	412 ○	3	,, 18	42 ○	13
,, 4	24 ○	13	,, 19	41 ○	32
,, 5	13 ○	42	,, 20	43 ○	12
,, 6	3 ○	124	,, 21	3241 ○	
,, 7	32 ○	4 1●	,, 22	32 ○	14
,, 8	31 ○	4 2●	,, 23	○	1324
,, 9	○	1324	,, 24	1 ⊙	34
,, 10	12 ○	34	,, 25	2 ○	134
,, 11	2 ○	134	,, 26	1 ○	234
,, 12	1 ⊙	24	,, 27	3 ○	124
,, 13	3 ⊙	12	,, 28	321 ○	4
,, 14	342 ○	1●	,, 29	32 ○	14
,, 15	43 ⊙	2●	,, 30	4 ○	32 1●

Configurations of Jupiter's satellites at 3^h *m* for an inverting telescope.

Satellite phenomena visible at Greenwich, $1^d\ 3^h\ 9^m$ II. Oc. R.; $4^h\ 40^m\ 15^s$ III. Ec. R.; $4^d\ 5^h\ 16^m\ 11^s$ IV. Ec. D.; $6^d\ 3^h\ 33^m$ I. Sh. I.; $4^h\ 51^m$ I. Tr. I.; $7^d\ 4^h\ 25^m$ I. Oc. R.; $12^d\ 3^h\ 54^m$ III. Tr. E.; $13^d\ 4^h\ 3^m$ IV. Tr. E.; $14^d\ 2^h\ 45^m\ 15^s$ I. Ec. D.; $15^d\ 2^h\ 11^m$ I. Sh. E.; $2^h\ 56^m\ 58^s$ II. Ec. D.; $3^h\ 29^m$ I. Tr. E.; $17^d\ 3^h\ 13^m$ II. Tr. E.: $19^d\ 2^h\ 32^m$ III. Sh. E.; $4^h\ 34^m$ III. Tr. I.; $21^d\ 4^h\ 38^m\ 57^s$ I. Ec. D.; $22^d\ 1^h\ 47^m$ I. Sh. I.; $3^h\ 3^m$ I. Tr. I.; $4^h\ 5^m$ I. Sh. E.; $23^d\ 2^h\ 39^m$ I. Oc. R.; $24^d\ 2^h\ 56^m$ II. Tr. I.; $3^h\ 10^m$ II. Sh. E.; $26^d\ 3^h\ 25^m$ III. Sh. I.; $29^d\ 3^h\ 41^m$ I. Sh. I.; $30^d\ 1^h\ 1^m$ I. Ec. D.; $1^h\ 45^m$ III. Oc. R.; $4^h\ 30^m$ I. Oc. R.

All the above are in the morning hours.

SATURN is an evening Star, 6° South-east of the Pleiades. Polar semi-diameter 8″. The major axis of the ring is 39″, the minor axis 17″. The ring is now approaching its maximum opening and projects beyond the poles of the planet.

The planet is too near the Sun for convenient observation of the satellites.

URANUS is a morning star, but badly placed, having been in conjunction with the Sun on January 24th.

NEPTUNE was in opposition on January 14th and is stationary on April 4th. Its motion may be traced on the map of small stars which was given in "KNOWLEDGE" for December, 1911, page 476.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
Mar. to May	263°	+ 62°	Rather swift.
April 12 to 24	210	− 10	Slow, fireballs.
,, 16 to 25	301	+ 23	Swift, streaks.
,, 18 to 23	189	− 31	Slow, long.
,, 20, 21	261	+ 36	Swift, bluish white.
,, 20 to 22	271	+ 33	Swift, conspicuous shower.
,, 20 to 25	218	− 31	Slow, long paths.
,, 30	291	+ 59	Rather slow.
April to May	103	+ 58	Slow, yellow.
April to May	296	+ 0	Swift, streaks.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 10^h to 14^h, next month 12^h to 16^h, and so on. In the case of Algol variables, the time of one minimum is given where possible, and the period. Algol, owing to its brightness, will be given for wider limits.

TABLE 22.

ALGOL STARS.

Star.	Right Ascension. h. m.	Declination.	Magnitudes.	Period. d. h. m.	Date of Minimum. d. h. m.
Algol	3 2	+40°·6	2·3 to 3·4	2 20 49	Apr. 4 0 57 *m*
ST Urs. Maj	11 23	+45 ·7	6·7 to 7·2	8 19 0	

NON-ALGOL STARS.

Star.	Right Ascension. h. m.	Declination.	Magnitudes.	Period. d.	Date of Maximum.
S Leonis	11 7	+ 6°·0	9·0 to 13	189½	May 4.
R Comae	12 0	+19 ·3	7·3 to 14	361⅘	June 8.
SU Virginis	12 1	+12 ·9	8·8 to 13	205	May 10.
T Virginis	12 10	− 5 ·5	8·2 to 13	339½	May 15.
T Can. Ven.	12 26	+32 ·0	8·6 to 11·8	290½	Mar. 26.
R Virginis	12 34	+ 7 ·5	6·2 to 11·1	145½	May 4.
RU Virginis	12 43	+ 4 ·7	7·6 to 11·8	440	May 26.
U Virginis	12 47	+ 6 ·0	7·7 to 13	206·9	May 29.
RR Urs. Maj.	13 23	+62 ·8	8·6 to 13	229½	Apr. 3.
R Hydrae	13 25	−22 ·8	3·5 to 10·1	425	Apr. 17.
T Urs. Min.	13 33	+73 ·9	8·8 to 13	321	Mar. 26.
V Urs. Min.	13 37	+74 ·8	7·5 to 8·7	71	Mar. 28.

XUM

CORRESPONDENCE.

A PHYSICAL PHENOMENON.

To the Editors of "KNOWLEDGE."

SIRS,—Two days after reading Mr. J. C. Clancey's letter, I came across the following passage in "Memoirs of Benvenuto Cellini, written by himself," about 1558. Translated by Thomas Roscoe. Page 295:—

"Another circumstance I must not omit, which is one of the most extraordinary things that ever happened to any man, and I mention it in justice to God and the wondrous ways of His providence towards me. From the very moment that I beheld the phenomenon, there appeared (strange to relate!) a resplendent light over my head, which has displayed itself conspicuously to all that I have thought proper to show it to, but those were very few. This shining light is to be seen in the morning over my shadow till two o'clock in the afternoon, and it appears to the greatest advantage when the grass is moist with dew; it is, likewise, visible in the evening at sunset. This phenomenon I took notice of when I was at Paris, because the air is exceedingly clear in that climate, so that I could distinguish it there much plainer than in Italy, where mists are much more frequent: but I can still see it even here, and show it to others, though not to the same advantage as in France."

TRESSILLIAN P. WIGGINS.

"WOODHAM MORTIMER," LEE, KENT.

THE NEW ASTRONOMY.

To the Editors of "KNOWLEDGE."

SIRS,—I write this letter to you in the hope of publication, as it contains the following challenge to the official astronomers of Great Britain. Can they give any explanation of the Spectra of Novae, without accepting *in toto*, Professor Bickerton's theory of the "Third Body" as an inevitable consequence of the partial impact of colliding suns, which he propounded nearly thirty-four years ago? Nova Geminorum is still blazing, and a most interesting series of spectrograms from it are open for their explanation.

During 1911, some time before the star above mentioned appeared, you published, in September and October, full details of the theory of the "Third Body," what Professor Bickerton concluded would be its life history, and the evidence, a light curve and varying spectra which must accompany such a phenomenon. Let us consider what he said, and what has taken place. A Nova shines for many months, and is not the actual collision of two suns; which may be of only short duration, perhaps lasting but an hour. With regard to this point Professor Barnard may be mentioned, as he has conclusively proved that neither a collision between suns nor that of a sun and nebula would have anything similar to the characteristics of a Nova: which is negative, but has an exclusion value in demonstrating Bickerton's thesis that the Nova is the "Third Body" shorn from the grazing suns, and his claim that every known spectrogram proves it. All astronomers who have studied stellar impact, from Lord Kelvin, downwards, have entirely overlooked the fact that they were regarding phenomena similar to the clash of flint and steel, in which each Nova was a cosmic spark. Professor Bickerton, alone, deduced this inductively, demonstrated it, and claims recognition upon the confirmation of all spectrograms of novae in existence. Once grasp this simple conception, and the triple mystery of these stupendous explosions called temporary stars, their thermodynamic power, unique light curve and complex varying spectra are explained in every detail. Can official astronomy otherwise account for them? The exploding "Third Body" has been entirely ignored, and one may search in vain through all recognised astronomic literature without finding any trace of its conception or comprehension; though it explains any observation ever made on a new star. One eminent astronomer though, I believe, admits there is such a thing, but only to say, "Why make such a fuss?" and deems it unworthy of further consideration. I shall await with interest any alternative explanation of the spectrograms already referred to. The accounts of the spectra from N Persei and N Geminorum in their earliest stages, the only two, I believe, ever obtained during the uprise of the light curves of novae, are similar to those of an ordinary star, with black lines, the hydrogen not having had time to escape. The next day all over the world spectra of the N Aurigae type were obtained, and the sequence deduced by Bickerton, showing the hydrogen escaping first in accordance with his theory of atom sorting and the formation of ensphering shells, vividly described in the articles in "KNOWLEDGE" referred to, was completely demonstrated, thus rendering the official enigma of these spectrograms so transparent that any intelligent child could explain them. Professor Barnard tells us he actually has seen this wonderful crimson hydrogen halo form and disappear; the first stage of the phenomenon named by Bickerton "Selective molecular escape." In a recent address given to the B.A.A., Professor Bickerton showed that in increasing perfection of detail, the South Kensington, Greenwich, Madrid, and Cambridge spectrograms of Nova Geminorum, combined with light curves, absolutely confirmed the majority of the principles of the Third Body he dynamically deduced and published a third of a century ago, and, as he aptly says, they leave no more doubt of the effect of solar collisions than the wrecked locomotives and telescoped carriages do of a railway accident. Yet official astronomy looks on in impotent silence, not apparently daring to admit the mistake of ignoring one of the greatest discoveries ever made. The scientific neglect of Bickerton's "Theory of Partial Impact" is deplorable and incomprehensible, but, unfortunately, not without precedent. To mention only the case of Mendel, thirty-four years elapsed before the value of his work was recognised, to the untold loss of humanity. It is just thirty-four years since Bickerton first published his epoch-making papers, and I hope, even now at the eleventh hour, that the generalization, for which he has sacrificed a third of his life, may be recognised as the basis of a greater astronomy and its concomitant, a valid optimistic philosophy.

SYLVESTER N. E. O'HALLORAN.

7, ALMA SQUARE, N.W.

THE ALCHEMICAL SOCIETY.

THE Second General Meeting of the Alchemical Society was held at the International Club, Regent Street, S.W., at 8 p.m., on Friday, February 14th. The Chair was taken by Mr. Walter Gorn Old, and a paper was read by Mr. Arthur Edward Waite (whose many translations of alchemical works are well known to students) on "The Canon of Criticism in respect of Alchemical Literature."

The lecturer dealt with the possible existence of a mystic element, in alchemical literature, from a very early period, side by side with the work of attempted metallic transmutation, and briefly traced its development. The lecturer further considered what is implied by the fact of this mystical element, whether it was a question of philosophical and theological doctrine or one of mystical practice and experience; and he pointed out the need of a canon by which to determine which alchemical texts are physical and which are metaphysical in their object.

The lecture and an abstract of the discussion has been published in the February number of the "Journal" of the Society.

STRETCHED FILMS OF LIQUID.

PROFESSOR C. V. BOYS' RAINBOW CUP.

By E. S. GREW, M.A.

ONE of the chief interests of the liquid film, as displayed, for example, in a soap bubble, is that its tenuity is such as almost to bring the observer within reach of molecules. An interest which is even more popular, and which is not on that account of less scientific usefulness, is the extreme beauty of the reflections of light from the double surface of a film. These are apparent in that commonest of objects, the soap bubble, but unless one has the manipulative dexterity of Mr. C. V. Boys a soap bubble is difficult to examine in detail or at leisure. At the anniversary meeting of the Royal Society, however, Mr. Boys exhibited a device which allows the least accomplished observer to vivisect a soap bubble, and to lay bare the changes which, owing to the progressive thinning of the film, it undergoes in its life history.

The device he has since called the "Rainbow Cup," a title which is readily explained by the most characteristic appearance of the film when stretched across the crater of Mr. Boys' Cup. The cup is a revolving brass drum, across the top of which it is easy to stretch a film or membrane of soap solution. When the drum is set spinning the film thins from its centre to its circumference, partly as the result of centrifugal action; partly, because where the upper and lower surfaces of the film join the edge of the drum a sort of suction pump action is continually going on. A film, which is practically a sandwich of liquid between two stretched skins, is always joined to a solid surface like the edge of the drum in a conical formation, roughly, thus:—

>———<,

and the V's at either end of the film are always sucking away the liquid in the film.

FIGURE 115.

Professor C. V. Boys' Rainbow Cup.

Now as everyone knows there is a constant play of iridescent colour on the surface of a soap-bubble. This is due to the rays of light reflected from it being reflected from the inner skin, as well as from the outer skin of the film, just as in a looking glass one may sometimes see two reflections, one image arising from the glass surface, the other from the silvered back. Consider now the case of red rays of a fixed wave length of light falling on the two surfaces of the soap bubble's film. If the two surfaces are exactly the proper distance apart, the waves coming back from the inner reflecting surface, may exactly meet and neutralise the waves reflected from the outer surface—the crests of one series of waves coming exactly where the troughs of the other series of waves are situated. If, however, the twin surfaces are "half a wave length of red light" further apart, or half a wave length of red light nearer together, the crests and troughs of the two sets of waves will not neutralise, but will reinforce one another. Thus we can easily imagine a red reflection from the film appearing and disappearing and appearing again, as the film thinned to appropriate dimensions. But the different colours of light have different wave lengths; so that when the film fails to reflect one kind of light, it may yet be reflecting another. The thickness of the film unsuitable for showing up the red or the pink may be suitable for reflecting the green: then as the film grows thinner the pink's turn comes again and the green disappears, and so into the other colours, the blues, violets, straw colours, into which during the whole of its life the film is analysing the white or yellow light falling on it.

These effects are apprehended, but are all mixed together on an ordinary soap bubble film: but in the film of Mr. Boys' revolving cup, the *regularly diminishing* thickness gives them an orderly succession. As the film becomes thinner the colours appear in circular rainbow bands in the following order, beginning with a film fifty millimetres of an inch thick:—pale green, pink, pale green, pink, bluish green, salmon colour, bright green, magenta, yellowish and then brilliant apple green, blue, purple, red, yellow, poor white, steel blue, purple, brown, straw colour, white, black. Each of these colours is related to its particular thickness of film which can be computed. The apple green is twenty millimetres of an inch thick. When the black is reached, far below the wave length of any light, the thickness of the film is only $\frac{1}{2000000}$th of an inch thick.

The black appears in a small spot at the centre of the cup (and of the spinning rainbow bands) and slowly grows. It can be made to grow faster by stopping the rotation and tilting the drum. Then the black film being thinnest and, therefore, lightest, passes upwards, to the higher edge of the drum. It continually eats its way into the other colours of the film and Professor Boys in his paper in the Royal Society's *Proceedings* surmises that the areas of black thus formed,

which assume the form of lines, streams, and meandering rivers, have steep banks. In certain circumstances a deeper black is set up within their areas, and this black film may be as little as the $\frac{1}{100000}$th of an inch in thickness. At that stage one is justified in supposing that hardly more than five hundred molecules are set end to end through the black film's thickness.

These divagations of the black aided by stopping and starting and reversing the rotation of the drum several times, are productive of a number of very beautiful patterns of colour: Persian shawl patterns, spirals, and an innumerable variety of groupings of colour. Perhaps nothing is more striking, however, than the appearance of the surface of the film when, a considerable quantity of black having been allowed to grow, the drum is again rotated. The surface then appears like the eye of some strange beast, with a huge black pupil and a rainbow coloured iris.

It will be comprehended, however, that beautiful as the colour patterns are they are neither the end nor the aim of this instrument, which enables many striking phenomena of the surface tension of films, as well as of their thicknesses, to be measured and examined. The black film's movements, for example, provide the means by which the existence of "line tension" as distinct from surface tension of a film can be made manifest. Along the margin of the black area there exists a tension of the order of $\frac{1}{1000}$th or $\frac{1}{10000}$th of a dyne, the latter amounting roughly to the nineteenth of a grain. A large number of interesting experiments illustrating the surface tension can be made; one of the most striking is that of laying a loop of hair or of spun glass on the film and of then treating the film within the area of the loop. The surface tension immediately pulls the loop into a perfect circle. Small bubbles of coal gas can be joined to the film, and in this case, as in that of the spun glass hairs, the portions taken up can be compared mathematically with the thicknesses of the film.

The "Rainbow Cup" is made by Messrs. John Griffin, of Kingsway, to whom we are indebted for the loan of the instrument from which our photograph of the film, with the central black spot, was obtained.

REVIEWS.

CHEMISTRY.

Leather Chemists' Pocket Book.—Edited by Professor H. R. PROCTER, M.Sc., F.I.C. 223 pages. 4 illustrations. 6¼-in. × 4¼-in.

(E. & F. N. Spon. Price 5/- net.)

This little book is not intended to take the place of a laboratory text-book, but to give in a convenient and concise form outlines of analytical methods and the various data to which the chemist may have occasion to refer in connection with leather. Among the subjects dealt with are the analysis of water, the recognition of vegetable tannins, the estimation of tannin, and the analysis of oils and fats. As a rule sufficient directions are given, but in some cases, where more detail would have been advisable, the reader is referred to the author's larger laboratory book. This is most noticeable in the section dealing with oils. For example, on page 147 the bromine thermal test is dismissed with the remark that it conveys little information not given more satisfactorily by an estimation of the iodine value. This is true; but it omits mention of the fact that the thermal method gives the result in five minutes, and is applicable to most oils and fats.

There is a useful section upon microscopical manipulation and another upon the general methods of bacteriological examination, which might with advantage be amplified.

The book, which is well printed and excellently bound in leather, should be found of constant use to the class of chemists and students for which it is intended.

C. A. M.

Radium and Radioactivity.—By A. T. CAMERON, M.A., B.Sc. 185 pages. 23 illustrations. 6¾-in. × 5-in.

(The Society for Promoting Christian Knowledge. Price 2/6.)

In a book intended for readers who have little or no previous chemical knowledge we look for simplicity of language and clear description which assumes nothing to be known beforehand. These conditions are well fulfilled in this little book, which gives a most readable outline of the discovery of radioactivity and the preparation and properties of radium. Interesting chapters are also devoted to the production of energy in radioactive changes and its bearing upon the estimation of the age of the earth; to the question of the transmutation of the elements; and to the uses of radium in medicine. The book is well illustrated with photographs and diagrams, and anyone who wishes to have a summary of the present state of knowledge on this subject cannot do better than obtain a copy. In the next edition it would be an improvement if an index were added.

C. A. M.

Lead Poisoning and Lead Absorption.—By THOMAS M. LEGGE, M.D. and KENNETH W. GOADBY, M.R.C.S. (International Medical Monographs). 308 pages. 4 plates and numerous diagrams. 8½-in. × 5½-in.

(Edward Arnold. Price 12/6 net.)

Though the units of the International Medical Monograph series are intended chiefly for medical men and for those whose work lies along the lines indicated by the titles of the individual volumes, yet the subject of Lead Poisoning is one of such national and international importance that the text book on it by Drs. Legge and Goadby ought to find a much more general audience. There is no Industrial disease which has attracted so much attention to itself as lead poisoning, and none in which the interests of manufacture have appeared to conflict more continuously with those of the workmen. It is not easy to perceive the reason of this, unless it may be that in a number of the industries where lead is used women are employed because the nature of the occupation does not require unusual physical ability, and that the effects of lead poisoning on women, who are more susceptible to it than men, have shocked the philanthropic community. Otherwise, it would be quite easy to show that lead poisoning is the cause of far fewer deaths and disabilities than arise in many other occupations; and, compared with the number of "accidents of occupations," the proportion of cases of dangerous lead poisoning is extremely small. The smallness of the proportion becomes more marked where specific trades, such as that of painting, are considered; for, contrary to general belief, painting is one of the healthiest trades.

It is, however, when all the trades in which white lead, or carbonate of lead is employed, are considered, that the number of cases of lead poisoning rises; and the reason for this is largely to be assigned to the ignorance of the nature and causes of lead poisoning. Dr. Goadby, who contributes the bulk of the chapters relating to the pathology of the disease, makes it quite clear that while lead poisoning may arise from any cause by which lead is infiltrated into the system, the chief danger arises when lead dust is inhaled. It is important, as Dr. Legge points out, that precautions should be taken by manufacturers, and should be enjoined, and as far as possible made compulsory, on workmen, to prevent them swallowing lead with their meals or in any other way; but it is far more important that regulations such as Dr. Legge describes and prescribes for drawing off the dust by fans should be made compulsory. Dr. Legge is one of H.M. Medical Inspectors of factories, and it is to be hoped that the strong line he takes on the necessity for the highest degree of precaution in the prevention and withdrawal of lead dust by mechanical processes will be emphasised by legislation.

Dr. Goadby's chapters on the physiological aspect of lead poisoning are a piece of brilliant pathological investigation. He shows indisputably the paramount influence of the inhalation of dust, and makes out very clearly the pathological conditions which give rise to minute hemorrhages throughout the organism, finally extending to the nervous system, and giving rise to the characteristic symptoms. He describes, also, an apparent form of acquired immunity to lead-poisoning, which appears among some workers; but it is evident that while such cases present themselves, there are others in which there is a specialised sensitiveness to the lead; and it is also evident that in such cases treatment may become very difficult.

E. S. G.

GEOGRAPHY.

The Lost Towns of the Yorkshire Coast.—By THOMAS SHEPPARD, F.G.S. 329 pages. Illustrated. 9-in.×5½-in.

(A. Brown & Sons. Price 7/6 net.)

This book, by the able and energetic curator of the Hull Museum, covers a much wider range than is indicated by its modest title. In reality it is a very complete geography of the East Riding of Yorkshire. Since Roman times, according to one authority, a strip of land averaging three and a half miles in width, or about one hundred and fifteen square miles, has been swallowed by the sea between Flamborough Head and Kilnsea. On the other hand the destroyer is sometimes stayed and land is even wrested back from him. Between 1848 and 1893, seven hundred and seventy-four acres were lost in Yorkshire, but during the same period, two thousand one hundred and seventy-eight acres were reclaimed within the Humber estuary. Many old towns and villages, however, have been washed away; but with the aid of ancient documents and maps, the author has been able to preserve their history, and even to indicate their former sites. The records of the lost towns occupy sixteen chapters. The rest of the book is taken up by a comprehensive geography of the district, which includes notes on the geology, natural history, antiquities, architecture, administration, agriculture, and the Humber mud. The latter is a particularly interesting chapter. The book is well illustrated and has been done with a thoroughness which makes it good reading.

G. W. T.

Map Projections.—By ARTHUR R. HINKS. 126 pages. 19 illustrations. 10 tables. 9-in.×5½-in.

(The Cambridge University Press. Price 5/- net.)

This book is written to meet the demand of those who approach the subject from a purely geographical point of view, whose mathematical equipment is not elaborate. But in addition to a knowledge of plane trigonometry and the rudiments of spherical, some acquaintance with the process of differentiation and its meaning is required for its perusal.

There are some obscurities here and there in the book. The writer has confused his symbols for the constant of the cone (pages 10–11, 76, 78.) The definition of this quantity given at the head of page 76 requires re-statement. Non-mathematical readers are not likely to be misled by expectations of mathematical nicety of phrase, and so not all will agree that there is danger in regarding the simple conical projection at first as obtained by the development of a cone. Some points not quite clear in the book are rendered so by this method of attack. Again, readers will find it inconvenient that the mathematical treatment of the various projections in use comes quite separately from the general discussion in chapter VIII. There is necessarily a good deal of mathematics in chapters II–VI, but as this is incomplete these chapters cannot be read intelligently without continual references to chapter VIII. Necessarily, too, the tables at the end are too meagre to be of much service even to those who are not primarily interested as cartographers. No one could expect to be able by the aid of a concise text-book to dispense with regular complete tables, and possibly the space devoted to them would have been more profitably devoted to extending chapter VII, which deals with projections in common use and the recognition of them, and is one of the most interesting and useful to this class of reader.

Many of these blemishes are incidental to a book which has not had very many forerunners, and in any case faults are always easy to find. On the whole, the purpose of the work has been very fully realised and it will be an acquisition to intelligent readers of geography. It is the best of its kind we have seen, and can be most heartily recommended to those who wish to begin the study of maps. Considering the limited appeal of books of this type its price is very moderate, and the get-up is of the satisfactory nature associated with the Cambridge University Press.

A. S.

MINING.

Safety in Coal Mines.—By DANIEL BURNS, M.Inst.M.E. 158 pages. 23 figures. 1 plate. 7-in.×5-in.

(Blackie & Son. Price 2/6 net.)

This book is written principally for colliery firemen, whose work is concerned with the safety of the mine, and on whose vigilance the lives of their fellow-workmen depend. It is intended for use as a text-book for the examination firemen have to undergo in accordance with the New Mines Act, and to furnish an account of the scientific principles which are the basis of their practical instruction. The first chapter contains a simple account of the elements of chemistry, especially in so far as gases are concerned. The next chapter describes the constituent elements of the mine gases. In the third the methods of detecting and testing the compounds and mixtures which form the mine gases themselves are described. The fourth and fifth chapters deal with air measurement and safety lamps respectively. The book is written very simply and clearly, and should well serve its intended purpose.

G. W. T.

ORNITHOLOGY.

Report on the Immigrations of Summer Residents in the Spring of 1911. Also Notes on the Migratory Movements and Records received from Lighthouses and Light-vessels during the Autumn of 1910. Edited by W. R. OGILVIE-GRANT. By the Committee appointed by the British Ornithologists' Club. 332 pages. 20 maps. 8¾-in.×5¾-in.

(Witherby & Co. Price 6/- net.)

The introductory section of this Report (the seventh consecutive annual one on the subject) is an admirably brief and illuminating comment on the contents which follow. These, as usual, go into great details, but no attempt is yet made to critically examine or co-ordinate the voluminous material which has been printed. The editor repeats his expression of regret at being unable to reduce the size of the Report and continues to give pages of records similar to those published for previous years and well known to the student. For example, particulars are given of the arrival of the Wheatear in Southern England, during the latter half of March, and these add nothing to the general knowledge of the occurrence of this species. It is the converse that would be noteworthy in this case, namely, a month of March in which the Wheatear did not turn up in the district named. The Report schedules the majority of our spring immigrants and gives a chronological summary of the records under each species, the movements of some being also illustrated by maps. Under the other sections of the Report, further observations are also made on these species (amongst others), and it would be a distinct convenience, in the absence of any index, to give references under the scheduled bird to the pages on which any further notes on the species are to be found. We have had occasion to look up the Land-Rail (Corn-Crake) and find that in addition to the main entries on pages 148–150, there are others on pages 209, 213, 214, 255, 277 and 302, all of which have to be puzzled out by the reader himself, unaided by any cross-reference. The great scarcity of this species now in south-eastern England is well illustrated by there being no records of it from the counties of Dorset, Sussex,

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Buckingham, Hertford, Essex, Bedford, Huntingdon, Cambridge, and Norfolk, and only few reports from Kent, Hants, Surrey, Middlesex, Berks, Suffolk and Lincoln.

Of the autumnal movements (1910) there are particularly good accounts of the Golden-crested Wren, and of the unusual irruption of the Mealy Redpoll (*Linota linaria*), which, during October, visited in numbers the whole line of the east coast from the Shetlands to Kent and many inland places. The first record of the Magpie as a migrant to our shores is remarked upon, twenty birds having been seen arriving at Thanet (E. Kent) from the north-east on 28th September, and fifteen from the north, during an easterly gale, on 14th October.

The Scottish records, which are so fully published elsewhere, are only partially utilised by this Report, and it might prevent misleading conclusions being arrived at, if Scotland, like Ireland, was excluded from the purview.

H. B. W.

PHYSICS.

Experimental Researches on the Specific Gravity and the Displacement of some Saline Solutions. — By J Y. BUCHANAN, M.A., F.R.S. 227 pages. 12-in.×9½-in.

(Neill & Co. Price 7/6 net.)

The author of this book, who acted as chemist and physicist on the memorable "Challenger" expedition, has made a close study of the subject of specific gravity for the last forty years; and the present volume is devoted to researches on saline solutions carried out during recent years by the aid of hydrometers. As usually constructed, the accuracy of the common hydrometer depends upon the correct calibration of the scale, which is marked off by reference to other standards; and hence most workers, when conducting precise work on specific gravities, employ the pyknometer in preference. Mr. Buchanan shows, however, that by standardising a hydrometer by reference to its own displacement, it is possible to secure results of a much greater degree of accuracy than is attainable by any method involving a series of weighings. Two forms of hydrometer are described:—the closed type, which may be made to sink in the liquid under trial by placing weights on the top, and which is used for the less dense solutions; and the open type, which may be weighted internally, and will, therefore, maintain its stability in the very dense solutions for which it is used. Full details of the method of standardisation are given.

The book contains the records of some thousands of observations, extending over some years, of the specific gravities of water solutions of a number of salts, ranging in strength from saturation to $\frac{1}{10\frac{1}{24}}$ of a gram-molecule per litre. Amongst the salts used are chlorides, bromides, iodides, iodates and nitrates of sodium, potassium, caesium, rubidium, lithium, barium, calcium and lead; and also various mixtures of salts in some definite proportion of their molecular weights. Many interesting relations between the specific gravities and displacements and the molecular weights are revealed as the result of accurate observations, and are shown in the form of diagrams and graphs. Of special interest is the graph on page 154, which represents the fluctuations in the increment of displacement in solutions of common salt ranging in strength from $\frac{1}{8}$ to $\frac{1}{1\frac{1}{8}\frac{1}{8}}$ of a gram-molecule per litre, the results indicating a series of interactions between the water and the salt at these low concentrations. It would be interesting to compare a water solution of a non-electrolyte, such as sugar, with those of salts in this connection.

An observation made incidentally with a supersaturated solution of calcium chloride is at once remarkable and suggestive. It was noted that this solution, prior to crystallisation, was in a state of unrest, undergoing a rhythmic series of isothermal expansions and contractions, which were detected by the delicate hydrometer used. Further investigation on these lines with other supersaturated solutions, and with suffused or overcooled liquids, is highly desirable; and might assist in diagnosing the cause of these abnormal states.

The effect of temperature upon the accuracy of the observations is discussed, and details given of the methods used to secure a constant temperature during the readings. A favourite working temperature was 19·5°C, which could most easily be attained and kept constant in the room. Many hints for accurate working may be gathered from the book, which may be recommended to all interested in the determination of specific gravities, and also to those engaged in the study of solutions, who may find in it suggestions for attacking the various problems from another standpoint.

CHAS. R. DARLING.

Elementary Physical Optics.—By W. E. CROSS, M.A. 311 pages. With many diagrams. 7½-in ×5-in.

(The Clarendon Press. Price 5/- net.)

When some years ago some Royal Institution lectures were delivered on Waves and Ripples in the Air and in the Ether, the lecturer, while describing and illustrating by many examples the wave motion of light, was obliged to consign his treatment of optical problems of deflection, refraction and dispersion of light on this basis, to an appendix to his lectures, subsequently published. Mr. W. E. Cross, who is the Head Master of King's School, Peterborough, has more boldly grappled with the difficulty. It is comparatively simple in illustrating geometrical optics to convince the pupil of their validity by using the "ray," or the line, as the unit; but having been taught in such a way it will be long afterwards before the boy will have arrived at sufficient proficiency in mathematics to draw any general conclusions from the experiments presented to him. If however the idea of a wave front, or advancing trains of ripples of light be presented to him, he will understand it, but he may find a difficulty in reconciling theory with experimental effects. After all a boy can see a ray, but cannot discern a light wave.

Mr. Cross compromises. He uses the ray in demonstrating the action of lenses, mirrors and prisms, but he explains their action by the change of curvature brought about in the wave fronts, or by change of velocity, when, as in refraction, the wave passes from one medium to another. By treating a ray not as a mathematical conception, but as a narrow cone of light, isolated from the wave series of which it forms a part, but possessing none the less all the properties of light waves, he arrives at a conception which causes no confusion of ideas, and in which there is no discrepancy between experiment and theory. The idea is not only sound: it is worked out so well as to give a solidity and an interest to the pupil's conception of the nature of light such as the older method cannot impart.

E. S. G.

RADIOACTIVITY.

Studies in Radioactivity.—By W. H. BRAGG, M.A., F.R.S. 196 pages. 70 diagrams. 8¾-in.×5¾-in.

(Macmillan & Co. Price 5/- net.)

This work by Prof. Bragg forms the latest volume in Messrs. Macmillan's series of Science Monographs. The volumes in this series are intended to represent "the expression of modern scientific work and thought in definite directions," and each volume will be by a specialist and mainly descriptive of his own contributions to the field of scientific work dealt with. They will thus be more adapted to the requirements of the advanced student than to those of the beginner. Prof. Bragg's book admirably fulfils the intention of the series, and he has very wisely not omitted to describe briefly the researches of other experimentalists, as well as his own most valuable ones, which come within the subject of the work.

Prof. Bragg's researches deal mainly with the passage of α, β, γ and X-rays through gases and solid bodies, the arrest, scattering and loss of energy of the rays, and their ionising powers; and he points out many close similarities (together with no less marked differences) in the behaviour of the three types of rays. Prof. Bragg considers that the corpuscular theory of the γ and X-rays will prove the more useful, and brings forth several interesting arguments against the ether-

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pulse theory. But these arguments all appear to be based on the assumption that the ionising power of the γ and X-rays is entirely due to their conversion into β rays, the latter being alone responsible for the ionisation. The experimental evidence offered for this assumption, however, seems somewhat inadequate.

H. S. REDGROVE.

ZOÖLOGY.

An Introduction to the Study of the Protozoa.—By E. A. MINCHIN, F.R.S. 517 pages. 194 illustrations. 8¾-in. × 5½-in.

(Edward Arnold. Price 21/- net.)

The recognition during the last decade or so of the extreme importance of the part played by the lowest of all animals in the economy of nature—and more especially as regards man himself—has led to the Protozoa being studied with an amount of labour and zeal never, perhaps, accorded to any other group of animals. And among those who have laboured hardest in this productive field is the author of the volume before us, who, with the true modesty of a great investigator, claims for his work only the position of an introduction to the vast subject he has made his own, and that it is not to be regarded as a complete treatise. To set forth all that is already known concerning the Protozoa would, he says, require a work many times as large. That the present volume is not intended for amateurs, goes without saying; its aim being to supply students who have at least some general knowledge of biology, with a means of taking up the study of the Protozoa in real earnest. How important to the biologist is this study may be gleaned from the single fact that, apart from all other considerations, it throws "great light on some of the fundamental mysteries of living matter—as, for example, sex."

In so wide a field it is essential to concentrate attention on particular aspects of the group, and Professor Minchin has, therefore, very wisely laid especial stress on the parasitic forms, both on account of the biological problems they present and of their intimate association with the practical needs of human life. The medical aspect of parasitic protozoans is, however, very properly left to the doctors, who are furnished by the author with a solid basis of fact upon which to work. In his concluding chapter, the author gives some most interesting speculations with regard to the origin of the Protozoa and the types which should be regarded as most closely approximating to the ancestral stock. In his opinion the nearest approximation to that stock would be "a minute amoebula-form, in structure a true cell, with nucleus and cytoplasm distinct, which moved by means of pseudopodia." To all workers on the subject Professor Minchin's volume is absolutely indispensable.

R. L.

The Childhood of Animals.—By P. CHALMERS MITCHELL, F.R.S. 269 pages. 36 illustrations. 12 plates. 9¾-in. × 6¼-in.

(Wm. Heinemann. Price 10/- net).

The subject of which Dr. Mitchell treats in such a fascinating manner in this volume is to a great extent untrodden ground, for although we all know that caterpillars change into butterflies and moths, and tadpoles into frogs and toads, while the young of many species of mammals differ to a greater or less extent from their parents in the matter of colouring, yet the meaning of these changes and the purposes of youth have never previously, we believe, been discussed in the thoughtful and thorough manner characteristic of the present work. The basis of the work was a course of lectures delivered by the author to a juvenile audience, at the Royal Institution, during the Christmas season of 1911-12; and although the work itself is not a printed version of the discourse, yet it tells the same story, although in a somewhat different and fuller fashion, more adapted to the requirements of adult readers. Although the work makes no pretence to be a complete treatise on such a wide subject, yet it covers a great deal of the ground, and records a very considerable proportion of published observations relating to that period of the life of animals intervening between birth and maturity. To review the volume in detail is not possible within our limits of space; and we can, therefore, only refer to a few interesting points. In the chapter on the duration of youth in mammals, it is pointed out that this period is longer among the more civilised than among the lower human races, and that in the former it appears to be still increasing in length. In rhinoceroses, horses, and tapirs the length of the duration of youth appears to vary according to the bodily size of the animals; and the same also holds good among ruminants, in which, however, owing to the advanced stage of development of the young at birth, the period of youth is unusually brief. Much interesting information is to be found with regard to the colour-patterns of young mammals, as contrasted with those of their parents. In mammals, the author believes that spots were the primitive type of colouring, and that these are connected with the tesselated nature of the skin. These spots may expand into short stripes, or coalesce into longer longitudinal or transverse stripes, which undoubtedly help to render the animals inconspicuous, although this is not the cause of their development. A uniform coat, which so often replaces the spots or stripes of the young, but may occur in the first dress of the latter, is apparently a specialised development; and the same seems to be the case when vivid patches of colour, which do not correspond with structural differences in the body, replace the first coat. In the latter case the object of the pattern, which, unlike the retention in the adult of a juvenile spotted coat, is generally more pronounced in males than in females, may serve, by breaking up the outline of the body, for concealment.

The book should be studied by all naturalists, as well as by the general reader.

R. L.

Elementary Entomology.—By E. D. SANDERSON and C. F. JACKSON. 372 pages. 476 illustrations. 8-in. × 5¾-in.

(Ginn & Co. Price 8/6.)

The writers of this well-illustrated volume, who are professors and lecturers in American science colleges, have found by experience that no text-books on entomology have sufficed for their needs; and they accordingly endeavoured to produce one which shall meet the requirements of both elementary students and their teachers. In this, so far as we can judge, they appear to have attained a high degree of success; for the book, without being unduly technical, conveys a good idea of the anatomy, life-history, and classification of insects, and this, too, in a relatively small space. Of especial value are the "keys" to the important families of the various orders of insects, which are evidently drawn up with great care, and the meaning of which is in many instances made plain by the aid of explanatory diagrammatic illustrations. The dominant note of the book is, as might have been expected, the economical aspect of the subject; for the old-fashioned cabinet entomology is, at least to a great extent, dead and buried, and the modern cult devotes itself to the life-histories of insects, and their *rôle* as carriers of infection to man and animals and their injuries to live-stock and crops. The authors, however, very wisely insist that an adequate knowledge of really useful economic entomology cannot possibly be acquired merely by a more or less casual study of the common injurious insects; and they have accordingly produced a work which should enable every student to obtain a thorough mastery of the elements of the subject.

R. L.

The Evolution of the Vertebrates and Their Kin.—By W. PATTEN. 486 pages. 309 illustrations. 9-in. × 6¼-in.

(J. & A. Churchill. Price 21/- net.)

In this handsome volume Dr. Patten, Professor of Zoölogy at Dartmouth College, Hanover, N.H., records his endeavour to solve one of the greatest and most difficult problems with which biologists are now confronted. As he remarks, vertebrates suddenly make their appearance in the geological record at the close of the Silurian or the commencement of

the Devonian, in the form of fully developed fishes. These are evidently a more highly organised type than any of the groups of vertebrates by which they are preceded; and it is obvious that they must have taken origin either from some of these preceding forms already known to us, by means of a strongly-marked transformation, or from other extinct types with which we are at present unacquainted. On either supposition, as the author observes, the missing links must date from the Silurian period: and considering the relatively large size of the earliest known vertebrates, it is a matter for surprise that these missing links have not yet been found. When we reach the Silurian "the main trunk of the animal kingdom, upon which the whole vertebrate stock rests, is lost, leaving, without reason or warning, a vast unknown abyss, beside which the gap between man and his immediate predecessors sinks into microscopic insignificance."

The annelids, the ascidians, *Balanoglossus* and its relatives have each been claimed in turn as the groups which came nearest to filling the gap; but Professor Patten will have nothing to do with any of them, and he pins his faith to the arachnids as representing, through the intervention of the so-called ostracoderms, the stock from which the great vertebrate phylum has sprung. And, to illustrate his views, he gives at the end of the volume an elaborate phylogenetic tree, whose roots are formed by the Protozoa, while mammals, birds, and reptiles form the topmost branches, with fishes branching off from the ostracoderms somewhat above the middle of the stem, and the latter, in turn, standing immediately above the arachnids. Not that the tree presents anything like a straight and unbroken trunk; for the ascidians, *Balanoglossus*, echinoderms, annelids, and a host of other forms, radiate out as complex lateral branches from near the base. Whether or no his views be generally accepted by morphologists, either wholly or in part, Professor Patten is to be congratulated on the completion of a most elaborate and valuable contribution to our knowledge of vertebrate evolution.

R. L.

Outlines of Evolutionary Biology.—By ARTHUR DENDY, F.R.S. 454 pages. 190 illustrations. 8½-in. × 5½-in.
(Constable & Co. Price 12/6 net.)

In claiming that biology should form one of the foundation stones of a modern system of education, the author points out that even an elementary study of biological theory should be preceded by a systematic course of laboratory work in zoölogy and botany. To aid students in this is the object of the volume before us, which commences with an account of a couple of primitive forms as a basis on which to explain some elementary ideas with regard to the nature of living things, and the differences between animals and plants. Then follows an account of the cell theory; while in later chapters we are introduced to the evolution of sex, variation and heredity, and the evolution of organic nature and adaptation to surroundings; while in the final chapters we have an excellent summary of the factors of organic evolution, commencing with a review of the works of the most eminent exponents of the theory of evolution, and ending with the evolutionary history of man himself. The whole subject is treated in a manner which should render the volume acceptable both to the beginner and to the student who has had some previous training; the freedom from unnecessary technicalities being a welcome feature. Among many interesting items, we have been specially enthralled by Professor Dendy's account of a peculiar organ in the head of a frog, which represents the last remnant of an unpaired pineal eye. We confess our own previous ignorance of the existence of such a structure in this well-known animal, but console ourselves by the thought that there are probably others who were in the same boat until they had read the many marvels revealed in Professor Dendy's excellent volume.

R. L.

YEAR BOOK.

Who's Who in Science—International, 1913.—Edited by H. H. STEPHENSON. 572 pages. 9-in. × 5¾-in.
(J. & A. Churchill. Price 8/- net.)

To this, the second issue of a most useful book, many additions have been made. The sections already appearing in the "Who's Who in Science" for 1912 have been enlarged, while Psychology and Geology have been added to the sciences represented. An important amplification is the list of the scientific societies of the world with their addresses and the many useful details about them. Endeavour has also been made to extend the list of the world's universities, and to supply the names of the principals, registrars and senior professors of all; but we are sorry to see that quite a long list of existing universites did not take the trouble to respond to the editor's request for information. We might emphasise the international character of the publication and say in conclusion it bids fair to be indispensable to every serious worker in science.

NOTICES.

USEFUL KNOWLEDGE SERIES.—We have received from Messrs. Hodder & Stoughton a list of new forthcoming publications, including the titles of the books coming under the above heading, as well as several for amateur gardeners and the first four volumes of the Open-air Series.

MACMILLAN'S NEW BOOKS.—The classified list of books issued by Messrs. Macmillan during the past month contains many dealing with scientific matters and education.

FRANCO-BRITISH TRAVEL CONGRESS. — It is intended to hold this congress in September, 1913, under the presidency of Lord Montagu of Beaulieu. From the proposed Agenda which has reached us, it should prove of considerable usefulness; and we notice in the first number of *France*, the official organ of the Franco-British Travel Union, which accompanies the Agenda, some interesting notes by Count Plunkett, F.S.A., on the Museums of France and Algeria.

THE JOURNAL OF THE ALCHEMICAL SOCIETY.—We welcome the appearance of a new journal, the first number of which (price 2s.) contains a paper on "The Origin of Alchemy" by our contributor, Mr. H. Stanley Redgrove, B.Sc., with a resumé of the discussion which followed its delivery. The journal is published for the Society, by Mr. H. K. Lewis, of 136, Gower Street, W.C.

A NEW COMPANY.—In future the business of Mr. J. H. Steward will be carried on by a private limited liability company under the style of J. H. Steward, Limited, at 406, Strand, London, W.C., from which address all outstanding liabilities will be discharged by the Company.

THE GOLDEN EAGLE.—Messrs. Witherby & Company, the publishers of "The Home-life of a Golden Eagle" have by special request prepared enlargements (measuring nine and a quarter by eleven and a half inches) of six of the principal photographs which were reproduced to form the plates in the book.

THE RAMBLERS' HANDBOOK.—The Federation of Rambling Clubs has issued for the first time a useful handbook containing many valuable hints and much information as to maps, houses of refreshment, ramblers' books, and so on, all for the modest price of 2d. The energies of the Union are primarily directed towards obtaining advantages for and giving help to the constituted clubs, but the good work which is done is helpful to all who ramble about the country. The Honorary Secretaries may be addressed at 25, Victoria Street, Westminster.

THE BRITISH ASSOCIATION.—For the meeting of the British Association, which will take place in Birmingham on September 10th to 17th next, the following sectional presidents have been appointed:—A (Mathematics and Physics), Dr. H. F. Baker, F.R.S.; B (Chemistry), Professor W. P. Wynne, F.R.S.; C (Geology), Professor E. J. Garwood; D (Zoology), Dr. H. F. Gadow, F.R.S.; E (Geography), Professor H. N. Dickson; F (Economics), Rev. P. H. Wicksteed; G (Engineering), J. A. F. Aspinall, M. Eng.; H (Anthropology), Sir Richard Temple, Bart., C.I.E.; I (Physiology), Professor F. Gowland Hopkins, F.R.S.; X (Botany), Miss Ethel Sargent, F.L.S.; L (Education), Principal E. H. Griffiths, F.R.S.; M (Agriculture), Professor T. B. Wood.